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EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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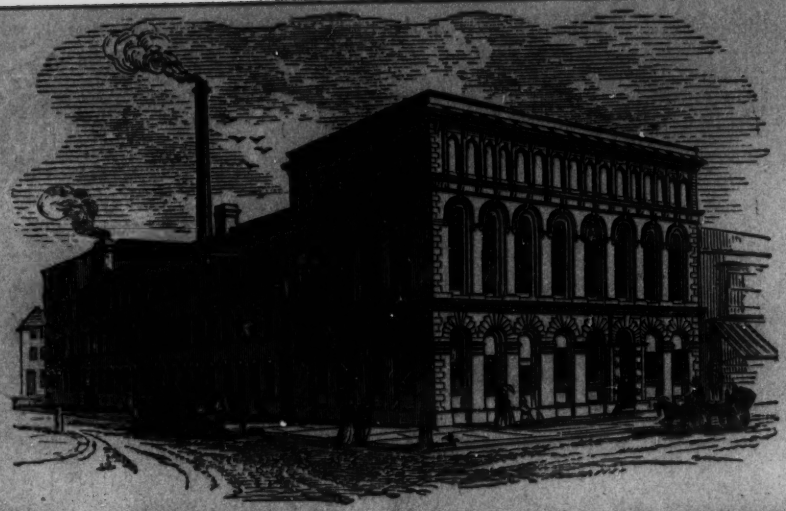

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Sketch Map of the Haute Loir

Loire and the Ardêche.

THE VOLCANOS OF THE HAUTE LOIRE AND THE ARDÊCHE.

By the Rev. W. S. SYMONDS, of Pendock.

(*Concluded from* p. 260.)

[PLATE VIII.]

WE shall long remember our days on Mont Denise when endeavouring to separate the newer geologic phenomena from the older. It was glorious sunny autumn weather, the distant views being wonderfully clear and distinct, and wild pinks blossoming wherever a tuft might grow among the cinders. There was *Dianthus superbus* and several other pinks which we did not know, with convolvuli and other autumnal plants, which were most abundant in the woodlands on the slope of the hill. The different views from various points of Mont Denise embrace the principal features of this extraordinary country. The following plants were noted by Sir W. Guise as growing on Mont Denise and near Polignac in the month of June: *Biscutella lævigata*, *Saponaria ocymoides*, *Coronilla varia*, *Dianthus* (two species), *Linaria striata*, *Mulgedium Plumieri*, *Rosa rubiginosa*, *Muscari comosum*, *Specularia speculum*, *Centaurea cyanus* and *calcitrapa*, &c.

Mr. Scrope believed that the noble ranges of basaltic columns, the Croix de la Paille and the Orgues d'Espailly, belong to the later volcanic outbursts from Mont Denise. The Croix de la Paille projects from the flank of the hill; but there are no means of determining the relation of this basaltic outflow to the tuff and scoriæ which cover the slopes of the hill, nor is it easy to say why these columnar rocks should not be as ancient as the older conglomeratic tuffs or breccias. The structure of the Orgues is very beautiful; and we are struck with the symmetry of the columns, which are 50 feet in height. The basalt overhangs the river Borne, but does not occupy the existing channel. There is an outlying mass also of columnar basalt, called Mont Redon, which has overflowed an ancient bed of the Borne at the height of 50 or 60 feet above the present channel. These

masses of basalt appear to me to have been local outbursts. A similar history belongs to the columnar basalts of Monistrol on the Allier south-west of Le Puy and Bains. They overlie old river beds of a former Allier, but are not excavated by the present river, for it now runs through the decomposing granite.

A pleasant walk from Le Puy through Brives and over the bridge on the Loire conducts us to a tributary of the Loire, and on the right bank of this stream is the Roche Rouge. This is a basaltic dike traversing granite, and is remarkable as showing the wearing away of the granitic rock by atmospheric influences, since the infiltration of the dike into a fissure, and the resistance of the Roche Rouge to the eroding agents. It is a romantic spot, the stream of the Lagogne flowing in a narrow channel through granitic rocks, and forming deep pools in which we saw trout shooting in and out of hollows in the rocks. Wild pinks were growing all around, and the tall pyramid of the Roche Rouge rises 200 feet above the river. The roadside between the river and the base of the basaltic dike exhibits an old river bed, many feet above the present stream. We traced the dike upwards nearly to the summit of the hill, and found that the granite immediately in contact with the igneous rock had decomposed much more than that at a distance from the point of contact. We observed also that, even on so isolated a spot, vegetation was far more luxuriant on the lava than it was on the granite. Wild flowers blossomed everywhere on the Roche Rouge, accompanied by butterflies hovering around, while hardly a plant flourished on the arid unfertile granite. Another dike cuts through the freshwater beds at Brunelet on the road from Le Puy to Issingeaux.

Standing on Mont d'Ours or any of the heights above Le Puy, and looking westwards, we see the granitic range of La Margeride rising between us and the old miocene volcano of the Cantal, while southwards are the heights of Mezen. Mont Mezen itself is nearly 600 feet above the sea; but the old volcano was probably much higher, as it was erupted on a much more elevated basis of granitic rocks than either the Cantal or the Mont Dore. Opposite Mont Denise, on the other side of the Borne, the basaltic plateau shows trachytic lavas overlying basalt, as if produced by separate outbursts. The demarcation of the two lavas may be seen even across the valley from Denise.

An expedition may be made from Le Puy to the ruined castle of Lardeyrolle, which lies on the left of the road to Issingeaux and Arnoray. Here, in the middle of the sixteenth century, lived the "terrible Baron des Adrets," who espoused the cause of the Huguenot king of Navarre, and who with one of his followers, Blacon, once a knight of Malta, and afterwards a freebooter, laid siege to Le Puy, and sacked the church of St.

Michel, but was defeated by the Catholics under the Count de la Tour Maubourg. Later on, the "terrible baron" and Blacon attacked La Chaise Dieu, mutilated all the statues and monuments in the church, and carried off the chandeliers, crosses, and vases. They also bore off a great statue of Moses, which they believed to be of solid gold. It turned out to be of copper-gilt; so Moses was most irreverently tossed headlong into a small lake, from which he was fished up again forty years afterwards. The ruins of the castle stand upon a conical hill of trachytic lava, which Mr. Scrope thought must have flowed from Mezen. These lavas should be compared with the tabular masses overlying the freshwater beds near Brives. Another fine ruin, in a romantic situation, within reach of Le Puy, is the castle of Bouzols, south-east of Mont d'Ours. In the Huguenot wars it was Catholic, or at all events was occupied by St. Vidal the Catholic Governor of Le Puy. Bouzols, Espailly, and Polignac leagued together; and M. Mandet, the historian of the civil wars of Le Velay, gives interesting descriptions of these feudal strongholds, and the way in which their lords taxed and levied contributions on the surrounding people without mercy. It was, it appears, owing to disagreement between Baron St. Vidal and the populace of Le Puy respecting the fortification of Bouzols that St. Vidal challenged Pierre de la Rodde to single combat, and was slain by a stab from his poignard.

The road to Bouzols from Le Puy is wild and peculiar, owing to the strange grouping of the hills capped with basalt, the excavated vales, isolated rock masses, and volcanic mountains away in the distance. The old Gaulish town of Monastier is situated on the borders of the great lava current of Mezen, while the castle of Bouzols stands on volcanic breccia similar to that of Corneille or Polignac, and rises in the middle of a great denudation of the freshwater and tertiary marls. It must have been a place of great strength, and with the light gleaming through its towers and loopholes is wild and weird enough. There are many local traditions about Bouzols, and a lady who was murdered by her cruel lord is said to haunt the place still. Below in the valley flows the Loire; and in front, to the south, rises the Lion de Coubon, a mass of basalt somewhat like a lion couchant. The basalt overlies a hill of freshwater marls, at the base of which is the village of Coubon. East of Bouzols is a valley of denudation in the freshwater strata, the valley of Lausonne, with lava streams overlying the hill platforms; while above these basaltic platforms rise the more recent volcanic cones of Prezailles and Freycenet. Another place particularly described by Mr. Scrope for its striking scenery and singular geology is on the Sumène river, a little north of Brives. Here we have the granitic rocks of Chaspinhac with its elevated vil-

lage, and these granitic rocks now separate the freshwater basin of Le Puy from that of Emblaves. The cone of volcanic scoriæ and cinders known as Mont Serre has been erupted on the edge of the granite escarpment; and the basaltic plateau, the Chauds de Fay, rests upon the freshwater beds. Here, too, are the Rochers de Peylencs, famous for their great blocks of olivine, specimens of which may be seen in the museum. This brecciated mass is very peculiar; surely the outburst must be local, and the blocks of olivine must have crystallized below the spot where they are now excavated. A great landslip has occurred, and let down masses of basalt, while the river Sumène rolls among a hurly-burly of *débris* and columnar ranges of basalt through a splendid gorge of rock and rushing waters.

The town of Le Puy is situated nearly in the centre of an area which was a large freshwater lake during portions of the Eocene and Miocene epochs. This ancient lake must have been at least twenty miles in length, by ten or twelve in breadth, and occupied a depression between hills of granitic gneiss; and probably the depression was caused by the subterranean movements preceding the great development of volcanic activity, which covered up the area occupied by the lake with lavas, breccias, and scoriæ. High granite hills must have risen all around; and there is little doubt that the granite peninsula of Chaspinhac which now divides the freshwater basins of Emblaves and Le Puy was a spur of high land jutting into what was in olden times a single lake. You might have sailed on its waters round by St. Paulien to Vaurey. It is probable that streams running from the same source as the present Loire and Allier flowed into the ancient lake; for it is evident, from old river drifts now elevated high upon hills where now no waters flow, that former rivers were compelled by land movements and volcanic eruptions to shift their courses over and over again. Our time was far too limited; and we only saw enough of Le Puy en Velay and its fossil remains to convince us that a series of events have occurred of magnitude and wonder, that are only yet foreshadowed to the geologist who searches for its past history, among silted-up lakes, ancient river beds, old granite hills, miles of lava torrents, and mountains of volcanic cinders and scoriæ.

From Le Puy to Vals.—There is a diligence from Le Puy through Pradelles to Langogne, a station on the Issoire Railway; but we strongly advise the geologist to make postal or other equine arrangements with our host at the Hôtel des Ambassadeurs at Le Puy, and avoid the diligence. Arrangements should be made also for horses to be sent on; for my companions, on a previous excursion a few months before, found that the best vehicle at Pradelles was a wretched "shanderadan," "and were dreadfully jolted over bonesetting roads."

We left at an early hour on a glorious September morning, and went along a steep road for several hours. When we had arrived at a height of about 1,000 feet above Le Puy, we saw a noble view of the surrounding country; but the basin of Le Puy was clothed in a dense fog, out of which the summits of Corneille and St. Michel towered like black island rocks. The great statue of the Virgin seemed to be looking over a still lake below; and the little church of St. Michel might have served for a lighthouse on a dark night for those who voyaged over its waters. Soon the sun dispersed the mist, and the scene was changed; the lake vanished, and was succeeded by a panorama of churches, houses, and the busy haunts of men.

The road the whole way to Pradelles passes over volcanic masses overlying granitic rocks, which are here and there exposed to view. We pass from the grapes and figs of Le Puy on to a wild sterile country, poorly cultivated, parts of which are heathy moorlands. Volcanic outbursts have been erupted through older sheets of basalts and lavas, all the way from Pradelles nearly to Brioude; but they have none of the characters of those of the Puys de Dôme in Auvergne—no craters, no modern lava streams running down the existing river valleys. This volcanic region appears to be of more ancient date than are the volcanos of the Puys de Dôme; everywhere the craters are degraded, and the ashes and scoriæ are spread about by denuding forces. There is one crater fairly preserved on the left, not far from the hamlet of Castaros, where we had sent on horses; but the grass covers the interior, and we saw no signs of a lava current having issued from its river or sides. Pradelles is a poor place and very dirty, so we recommend a halt at Peyrebelle in preference. The country round Pradelles is wild enough; and that it was once wilder appears from the fact that Mr. Scrope counted 150 volcanic cones about Prezailles to the N.E. of Pradelles. Before arriving at Peyrebelle, the house was pointed out to us where a dreadful series of murders were committed some forty years ago. The proprietor, Pierre Blanc, kept it as a roadside inn; and when he found out that any of his lodgers were possessed of money he murdered them in their sleep, and, with the aid of his wife and servant as accomplices, threw their bodies down a pipe into a large oven, where they were consumed. At last they were detected, and were all executed, close to the scene of the murders. The oven has been taken away, and the pipe built up; but the house still remains, and a dreary place it is. The hostel at Peyrebelle is rough, with the stable and cowsheds underneath the salon and sleeping apartments; but we found the landlady obliging and the cuisine excellent, and I should say that a geologist might make this his head-quarters for exploring the Mezen and the country round the sources of the Loire.

We are here on the plateau of Pradelles, which separates the Loire and the Allier, and within reach of many interesting localities and beautiful scenery; while to the fisherman it holds out the choice of many streams, full of goodly trout, within a walk—at least, so said our driver. Our road lay by La Chavade, along the flanks of the granite range on which rises the Loire. The whole scenery is changed as if by magic, and we find ourselves in a sub-Alpine district, among gorges and rocks and running waters. The road descends for seven or eight miles in a series of zigzags, and we had an opportunity of forming an idea of the disintegration of the granitic rocks from the wear and tear of atmospheric agents. The previous summer had been wet, and masses of granite had fallen from the mountains down the side of the gorge in heaps. At one place above the river the road had been carried away for many yards, and a large body of workmen were engaged in the repairs. We had to descend from our vehicle, and a day earlier our passage would have been impossible. Beyond this, fallen masses lay here and there in the road; so this route, after a storm, is not without danger. On our right was a river flowing far below, and across the valley rose granite hills—the source of the Allier—covered with the great forest of Bouzon, still the haunt of the wild boar and the wolf. Volcanic cones have in two or three places burst through the granitic district near the source of the Ardêche river, but have sent forth no lava streams into the valleys.

The people of Le Puy have a habit of altogether ignoring the existence of Vals, where there are several excellent hotels, especially the Hôtel des Bains, and of recommending the tourist to stop at *Thueys* for the Montpesat and Jaujac scenery, whereas Vals is only six or seven miles farther on. One line on the accommodation at Thueys in the summer of 1875, from the note-book of Sir William V. Guise, may be a warning to the tourist:—"But how to describe the so-called hotel! the dirt, the squalor, the smells of that most primitive of hostelries!" And then there was an "extortionate hostess," and all the while comfortable and cleanly Vals a few miles beyond. Still, Thueys is a place to visit from Vals, for it stands upon a great current of lava which has been poured from a volcanic cone east of the village. The columns of basalt are very grand, and nearly 150 feet in height. The river Ardêche has cut right through this basalt down to the granite below; and here, as in other localities in this country, we find the granitic rocks yielding much more easily to the flow of the waters than does the basalt. The river is now excavating the granite bank. The cone of Thuey is not far from the volcano of the Gravenne de Montpesat, but is much

smaller, and has no crater. Its lava flowed into the channel of the Ardêche on the south of the granite ridge, out of which it burst; while that of the Gravenne was erupted down the bed of the Fontaulier on the north of the ridge. In the summer the botanist should look for a good plant, *Nothochlæna maranæ*, which grows on the basalt above the sides; as also does *Spiranthes æstivalis*. *Carduus vivarensis* and *Cephalanthera rubra* were found here, as well as in the crater of Jaujac, in the summer months, by my friends Mr. John Kent and Mr. Elmes Steele, who botanized over this district in 1874. When we were there in the autumn the base of the hills was clothed with *Dianthus hirtus, prolifer*, and *superbus*; and from the same neighbourhood we gathered *Taraxacum gymnanthus*, *Chondrilla juncea*, and *Borkhausia fœtida*. We here saw the Camberwell Beauty (*Vanessa antiopa*) flitting along the great walls of columnar basalt above the river.

Vals is celebrated for its mineral springs. It lies in an amphitheatre of low wooded hills, and through the beautiful village flows the Volane stream, which is a tributary of the Ardêche. The source of the river Volane is among the granite mountains above Antraigues, and the most remarkable volcanic scenery in southern France. The time must come, when the railway is open from Montelimart to Aubenas, when Vals will be more frequented than any of the thermo-mineral sources of La Belle France. The mountain streams are full of fish, for they are but little fished; and we saw red-legged partridges and quail, and feasted on wild-boar hams from the forests on the mountains. The cuisine was excellent at the Hôtel des Bains, and the horses were strong and able. To the artist, geologist, and botanist the surrounding country is singularly attractive; indeed, it is extraordinary in more than one of its characteristics. The drive from Vals to Montpesat is about twelve miles, and is one of rare beauty and interest. We pass through the village of La Baume, which is itself quaint and interesting, and would serve as quarters for a few nights to those more active geologists who do not object to a little roughing. I would invite the attention of all geologists to a section on the right bank of the river, above the bridge at La Baume, and nearly opposite the ruined castle of Pourcheirolles. Here the columnar basalt, which runs like a vast wall by the river side, has been blown through by a "chimney" of volcanic ash and scoriæ, evidently of later date than the outpouring and consolidation of the basalts. Higher up the river the Baume basalts may be seen, overlain by an ancient river bed. Some time since I threw out the suggestion in "Nature" (No. 317, Vol. XIII.), that these volcanic outbursts and eruptions through basalts may have happened even in historic times; for the

Archbishop of Vienne, in the fifth century, mentions the occurrence of "frequent shocks of earthquakes," "fires often blazing," and "piled-up mounds of ashes," in this part of France. The geologist will see along the banks of the Ardêche and other streams an example of the power of swollen rivers in removing large masses of rock; indeed, nowhere have I seen better examples of transportation of rock masses by river floods than in this country. The ruins of a seignorial castle of Ventadour are grand as seen from the "chimney" just alluded to. The river bed has once been filled with a torrent of lava; but the victorious waters have again excavated a channel to the former level, and exposed the old river gravels, covered by the basalt. Hills of red cinders rise among the granite rocks, whose base is clothed with noble chestnut trees; and the peasant trains the vine on the sunny slopes, little mindful of the "ignes suppositos cineri doloso."

On the road to Montpesat is a small mineral spring called "Pestrui," which affords a sparkling chalybeate water, very refreshing and agreeable to the taste. Large hampers were being sent off filled with bottles of the "Pestrui eaux," considered excellent for gout and dyspepsia. Great quantities of the edible fungus *Boletus edulis* grew beneath the chestnut groves. The peasants of the country are well aware of its excellence, and consume it in great quantities. We had a large dish, garnished with fresh trout, at Montpesat, which would have been highly appreciated at the fungus foray of the Woolhope Club. The local name is "Ceps de Bourgogne." Here, too, we saw two or three specimens of a beautiful green Mantis, or praying insect, and, though late in the season, a good many butterflies. The "Gravenne of Montpesat" rises boldly on the left, with its red cinders, out of groves of chestnut trees and pines. The term "Gravenne" is derived from "gravier," or gravel, to which the loose cindery surface of the cone is not inaptly compared, and a neighbouring cone is called La Gravenne de Souillols. The crater from which the mass of scoriæ and cinders which covers the side of the cone have been erupted lies on the side immediately above Montpesat, and the surface of the cone is strewn with granitic *débris* blown out of the crater during eruptions. A lava stream has poured into the bed of the Fontaulier, which, below the ruined castle of Pourcheirolles, meets another lava stream coming down the bed of the Pourseille. The summit commands a grand view of granite mountains, profoundly scored in deep gullies, with volcanic cones rising abruptly from their flanks. No word-painting can do justice to the scene selected by Mr. Scrope for his admirable illustration of the "Valley of Montpesat" (Pl. XIV.) in his "Volcanoes of Central France." The position of

the ruined castle as seen a little below Mr. Scrope's sketch, and from the river, is quite startling, so grand and picturesque is the surrounding scenery. The river runs through dark frowning cliffs of columnar basalt, above which rise green groves of chestnut trees, and on the left the red volcano of Gravenne. Then in front stand the ruins of the old castle, rising sternly from what appears to be an island of basalt, but which is really a peninsula excavated by rivers which flow on either side. Then high above all rise white granite mountains, so white here and there that you may fancy them capped with snow; and behind all and above all, the bright blue sky of the south of France. So wonderful is the colouring of this scene, that Sir W. Guise was occupied for hours, and came away dissatisfied. I remarked here, as well as at La Baume, that the basaltic lavas had been shifted in places by later volcanic outbursts—attempts to establish a volcano, but which have failed sometimes even to form a "chimney." We cross to Montpesat by a good bridge, and the sections on the two rivers, as seen from the castle, are very fine. The castle is perched on the extreme end of a peninsula of basalt, the point of junction of two rivers, the channels of which had been filled with torrents of lava, but through which the rushing mountain streams have again cut their way down to their former level, through the old excavated granite.

The Pourseille lava stream was erupted from a volcanic cone, up a valley in the mountains behind the village—a wild hill walk, which leads to Burzet and the sources of the Loire.

We were told that wolves were so abundant around Burzet during the war between France and Germany as to have become an absolute nuisance to the inhabitants of the mountain villages. It was supposed that they migrated from other parts of France, and had taken refuge in the forests of the Ardêche. Several children were destroyed during the winter months. Of the habits of the wild boar the people appear to know very little excepting that they were best to eat when fattened upon chestnuts. Chestnuts are here distinguished as "marrons" and "châtaignes," the "marrons" being the finer. Sir William Guise's list of summer plants includes *Silene rupestris*, *Scleranthus annuus*, *Cephalanthera rubra*, and *Dianthus cæsius*.

The expedition to Jaujac should be made so as to see both routes, viz. the one by the valley of Carboniferous rocks enclosed in a granitic hollow, and the return journey by the valley of the Alignon to La Baume. We quit the Vals and La Baume road about six kilometres short of La Baume, at a point called Les Mines de Prades. Coal has been worked here, but does not appear to be of much economical value, as might be expected from its position. The strata are highly inclined, and without doubt are much crushed and dislocated. The cone of Jaujac, called "La

Coupe de Jaujac," has been erupted through the coal measure rocks, and has a large and perfect crater covered now with chestnut trees, but within which grow several good plants, such as *Dianthus cæsius*, *Cephalanthera rubra*, and *Convolvulus cantabricus*. *Silene saxifraga* grows on rocks in the bed of the Alignon.

The village of Jaujac stands upon the lava torrent which came down from the crater, dammed up the river Alignon, and for a time formed a lake above. We were there on a Sunday; and the people were all dressed in their best, the women at mass, and the men smoking and playing dominoes in the inns. The vineyards on the slopes of the hills between Jaujac and Thueys were clustered with grapes, which were being gathered, and a well-dressed woman presented me with as many as I could bring away. Here we met a priest, who addressed us on the geology of the district, and who knew Mr. Scrope and M. Elie de Beaumont apparently better than he did the geology of his own country. The walls of columnar basalt at Jaujac are very striking, and are seen in contact with the old land surface over which the lava flowed. Very different, too, is the quality of the land since the overflow by the basalt. The decomposition of the lava plateau forms a rich generous soil on which grow the mulberry and the fig. The granite is sterile enough, and requires constant aid from manures. Walking for some distance down the river, we could see that the thickness of the basalt could not be less than 100 feet, and we observed that, in passing over bosses of granitic rock the lava had crystallized in prisms at right angles to the inclination of the surface over which the lava flowed. In this splendid river section three points of geological interest are clearly to be seen. First the river Alignon flowed in a channel between granitic and Carboniferous rocks as deeply as it does at present; then came the outbursts from the Coupe de Jaujac, which filled the old river bed with lava and dammed the river; then the river flowed over the basaltic plateau, and since that has cut its way down through 100 feet of solid lava to its present level. On the left bank of the river below the bridge there is a corner below the hill before ascending the pathway to Thueys which looks like a young "chimney," for the basalt is partially dislocated, and there is a little outburst of volcanic sand. Below the village of Nerac prismatic columns of lava may be seen resting on the rolled pebbles of the old river bed.

We went to Antraigues for the Coupe d'Eyzac, distant about five miles from Vals. The road follows the course of the Volane river through a romantic gorge, which leads up to the granite mountains of the Haute Vivarais. This valley differs from the others, inasmuch as the basalts appear to have been

more denuded, for they are seen in patches of columnar lava, clinging, as it were, to sides of granite. The shingle of the old river bed is seen in one or two localities on the right bank overlying basalt, and at an elevation of 80 or 100 feet above the present stream. The village of Antraigues is very picturesque, situated on a lofty rock, at the foot of which flows the Volane in a deep rocky channel. On the path leading up to the village stands an isolated rock, about 30 feet high, of twisted basaltic columns, resting on granite. This rock is a most remarkable monument of the denuding powers of atmospheric in-

"Le Pain de Fromage" (sketched by Sir W. V. Guise, Bart.).

fluences. It is evident that the basalt had flowed into a fissure in the granite, and that the granite walls have since been denuded. It is known by the name of "Le Pain de Fromage." The crater of the Coupe is broken down on one side; but the hill well repays the ascent, for the view commands the Coiron range, and we can see the capping of basalt from the point where it was poured out from the granitic base near Le Gua, to flow away in the direction of Privas, where it covers Jurassic and Cretaceous rocks, in widely-spread plateaux. On the other side

Aubenas glistened in the sun, and we thought we saw the Alps of Dauphiné dimly through the haze.

Aubenas is situated on a lofty eminence above the Ardêche, which flows far below, and is crossed by a stone bridge. The prospect from the parapet in front of the great square is wonderfully extensive, diversified as it is with woods, villages, and cultivation; the Coiron range, capped by basalt, just opposite, and lofty granite mountains rising to the north. The brown old town has quite a mediæval aspect, and from its situation must in olden times have been a stronghold. The Hôtel de l'Union is the best, but very inferior to the hotels at Vals. There are, however, diligences from Aubenas to all parts of the surrounding country, so that the geologist may easily start by one of them at an early hour in the morning, and walk back. The opening of the railway to Montélimar will much facilitate the exploration of this country by naturalists. On the right of the road in ascending to Aubenas we see sections of Jurassic rocks. These rocks are of Liassic age I believe, but we saw no fossils. They are traversed by a dike of augitic greenstone which forms the summit of the hill.

From Aubenas to Montélimar the scenery changes altogether; and nothing can be more different than is this drive as compared with the scenery of Jaujac and Montpesat, yet most interesting to the geologist. There is a grand section of Jurassic strata across the Ardêche, very similar in mineralogical appearance to the Lima beds of the Lias; and, as the ascent is of long duration, we had several opportunities of looking for fossils, but found none.

Between Aubenas and Villeneuve de Bere, we had an opportunity of observing the way in which masses of basalt strewed the plains; every wall is built of them. This *débris* is a relic of the denudation and degradation of the escarpments of the Coiron hills wearing backwards. Beyond Villeneuve we have fine views of the great headlands of the Coiron mountains, and their dark cappings of basalt, the source of which we longed to investigate from Vals, but were prevented. Mr. Scrope believed that these basaltic currents flowed from the Mezen; but there are one or two objections to that idea. There is no basalt whatever overlying the granite for several miles, between a place called Le Gua, north of Antraigues, and the volcanic eruptions near the sources of the Loire. Again, Mr. Scrope mentions that the well-known land-shell, *Cyclostoma elegans*, has been found in old land surfaces underneath the Coiron basalts. This does not look as if the Coiron basalts were as old as those of the Mezen. Be this as it may, the geologist cannot fail to be struck with the lapse of time indicated by the erosion of vast masses of strata, the effects of frosts and snows, rains and rivers, since the basalt

of Coiron flowed over a great plain of secondary rocks, which abutted against the granite, and protected it from denudation. Since that period great valleys have been excavated, and the configuration of the country has been entirely changed. We saw in several places the excavations of the railway from Montélimar and gathered on the limestone *Centaurea cœrulescens* and *aspera*, *Æchinops libro*, and *Campanula media*. Leaving on our right the ancient city of the Helvii, Aps, our last view of volcanic rocks was the Roche Maure, which in 1751 led MM. Guettard and Malesherbes to the discovery of the volcanos of Auvergne. What changes have happened since those days; what progress in geological knowledge! The "Principles of Geology" had not been penned, and the tertiary shells of the Apennines were supposed to be the scallops of the pilgrim. It was dangerous to doubt the fact of a universal deluge, or that the world was more ancient than some 6,000 years. The older rocks were but a chaos, and no Lyell, Sedgwick, or Murchison had appeared to throw the vigour of a lifetime into a labour of love. Yet the investigations of the geologist are inexhaustible; and among hills and valleys the most romantic, in beautiful southern France, where the wild rose blossoms on the red cinder of the volcanos, and chestnut forests cluster at their base, there are problems to be solved, and shrouded fossils to be disinterred, which shall yet throw light upon the extinct volcanos of the Ardêche.

FLINT IMPLEMENTS.

By Captain C. COOPER KING, F.G.S.

[PLATE IX.]

THE study of prehistoric archæology, though comparatively one of modern origin, has made rapid strides towards systematic development and classification during recent years. The probable chronology of the earlier races of mankind has been so far examined as to admit of the definite grouping or arrangement of their relics into periods of greater or less duration, and of more or less defined limits. Thus it has been recognized, after much controversy, that the drift gravels of river valleys, and many caves and rock shelters, contain stone implements coeval with the remains of the Mammoth, Rhinoceros, Cave Bear and other animals long since extinct. These, of which the St. Acheul specimens offer the best known examples, have been denominated Palæolithic implements—rough chipped tools of old time. Next to them in order have been placed implements of higher art; those of polished stone, of the Neolithic age. After this came the bronze period, when metal took the place of stone; and this was soon followed by the age of iron, the first days of which overlapped that of bronze. Its early dawn was prehistoric, its ripe manhood modern. And so rapid was human progress when the metal more difficult to work, and requiring more skill in its manipulation, began at last to be generally used for warlike and domestic purposes, that the iron man soon ceased to have no other records than those of the implements he manufactured. Iron man soon ceased to be prehistoric.

But there are other relics of human handiwork, less definite than those of the three great ages, into which early human history has been divided. These may be classed as "surface finds;" for they are the probable result of merely temporary occupation of certain sites for brief periods of time, and may belong to any age. The amount of skill evidenced by the rough remains found in these cases is the only guide as to their antiquity; though even then the degree of excellence is not a

Implements.

True

False

Flakes

a

b

c

(Bulb.)

c

Top surface

True (wavy) edge.

False (crushed) edge.

d

True wear

e

Crush wear

Cores.

Vertical

Pyramidal

Hoof.

f

g

h

i

k

l

m

Briquet

Bone splitter.

Thumb scraper

n

o

p

Notched edge.

Perforator

Circular scraper.

C. Cooper King, F.G.S.

Flint Implements &c.

W. West & Co. lith.

certain test, for some tribes may have been more able than others in the manufacture of temporary tools. No highly artistic weapons are to be found as a rule there, for the wandering families would retain with them their more valuable implements; and these ancient camping grounds were occupied apparently only for the brief halts necessary for rest and repose, so that the duration of the stay would be too brief to admit of much careful work.

Polishing and skilful finishing of tools is the result of time and continuous labour. Even if better implements of bronze, or iron, or polished stone were carried by a nomad tribe, these would be all too valuable, too precious, to be used for the ordinary occupations of life. "Surface finds" may belong to the Neolithic, bronze, or even iron ages; for the travelling bands or families halting for the night at some favoured place would be able, in most localities, to find rough flints, out of which rough flakes for knives, rough tools for work, rough "strike-a-lights" for fires might easily be made. If there were any doubt in the mind of the head of the household, a very few flint stones carried by the women or children thereof, would enable the necessary implements to be fashioned when the camp was pitched. So that scattered in patches over vast areas of country, on the old lines of road or communication, the sites of old camp fires may be marked by flint-chips and even rough implements.

In the southern part of the valley of the Thames, between the river itself and the Guildford hills on the one side, and the two great cities of Londinium and Silchester (both prehistoric sites of occupation, one being the capital the other the centre of tribute of South-eastern England in Roman times), on the other the traces of successive occupation are common. In the valley of the Thames are remains of animals, long since extinct, buried in gravel beds marking different levels of the river. Elephant and cave bear, hyena, and the great *Bos primigenius* drank of its waters in old time. In its higher-level gravels have been found, in places, true Palæolithic implements. Over this area, crossed as it is by Roman roads, marking old lines of communication, prehistoric tribes, tribes of Saxons, and Roman legions have passed and left their trace.

Upon Easthampstead plain is a tumulus that contained implements of polished stone and rough pottery. On the Hartford Bridge flats is another. Near it was found a fine polished celt, now in the possession of Mr. Raikes Currie. At Wickham bushes, near Broadmoor Asylum, are fragments of old tiling, old pottery of Romano-British or Saxon work. On the road between York Town and Frimley, at the foot of Prance Hill, were dug out at a few feet below the surface, Romano-British cinerary urns. In the gravel of Reading, at the junction

of the Thames and Kennet, some twelve feet down, was discovered a Saxon javelin of iron, the relic of an iron age, that of invasion and thirst for conquest. The barren flats of the Eastern and South-eastern highlands of England abound in such history. On the great Roman road between Silchester and Windsor was found a Roman statue now in Mr. Waterer's garden, at Bagshot, through which the road ran. And over this land, so often traversed by successive races, "surface finds" are common. Near the Staff College in the Wishmoor Valley, farther down the banks of the rivulet that drains it, all along the slopes of the Hog's Back, near Guildford, by which the great line of traffic from Southampton to London and Canterbury was carried, "surface finds" in perfectly defined patches are to be found by those who seek.

Now what are the signs of the existence of an early race?

First of all we must remember that, speaking very generally, the old lines of traffic are used still. Newer ones may have been made since, as forests were cleared, morasses drained, and rivers bridged; but the old roads leading to fords that existed then and exist now, old road lines occupying the dry high lands over the ill drained low lands, still mark lines of intercommunication.

Modern sites of occupation are frequently old ones too. Our ancient village churches indicate old centres of habitation where British villages or pit dwellings once existed.

Our first requirement, then, is the old line of traffic or trade.

Next reduce ourselves to the condition of a savage. Assume for a moment we had no house or shelter, no utensils of any size to carry water, the roughest of coverings for the feet, the most primitive garments for the body. Where should we seek to camp under these unpleasant circumstances? On dry land near water firstly. Out of the cut of the east wind, under the shelter of a hill or wood next. Human nature was much the same then as it is now. Such comfort as those early days could give would certainly be sought for.

And so we find the local habitations of prehistoric man. Mere surface collections of broken flints; but still they are broken with intent, and the flakes are numerous, and similar in character. Even more than that, they are in purely local groups.

Enter a large field that may seem to be promising and to fulfil all the conditions required. It may be full of broken flints, plenty of questionable fragments may lie near you; but it is probably only in one small area, such as the circuit of a camp fire, that abundant traces of human work may be found. Generally they were mere halting places on the line of march. Rarely on the road itself, but, as a rule, under shelter from weather and away from the track on which, at night, marauders might be on the watch.

By the side of the camp fire the old Archaic man repointed (that is re-chipped) his axes and refashioned his arrow-heads. Sometimes the flint broke unkindly, and it was flung aside as a broken knife would be.

As an American would whittle a chip, as a boy amuses himself by carving a boat out of a block of wood, to pass the dull evenings of winter, so, we can well imagine, the Archaic boy, copying his elders, learnt on his own account to chip and fashion flints. The evening meal had to be cooked and the "strike-a-light" came into requisition, to be cast aside when done with, for any other piece of flint at the next halting-place would do as well. And remember his materials for fire-making were very simple. A piece of iron pyrites, some vegetable fibre, and a flint stone. It must have often taken a long time to get a light in damp weather. Many chips must have been knocked off uselessly with cold hands and such rough material.

No wonder, then, that "briquets" are numerous and are much worn. But the meat had to be cut, the bones well scraped, perhaps even the finer ones converted into needles, or arrow-heads, and for this longer flakes would be required.

So from larger blocks long sharp-edged flakes were struck off and used. Some of these rough blocks, when so denuded, were sharp enough for blunt chisels; others could be made so by breaking them across at a sharp angle, like a rough mortice chisel, as Dr. Gillespie has suggested. With these, stakes burnt in the fire could be roughly shaped down to a point to form stockades, &c. When the occupation of the site lasted for any time it may have been thus protected with stakes and wattle.

Remember there was no iron to dig with; only sharp-edged stone to use for cutting purposes. Then skins had to be dressed down, scraped with a thumb-shaped flint which would rub and not pierce or cut them. Needles were wanted and were shaped from fragments or splinters of the bones of rabbits and birds by flint flakes, and the eyes bored with a small pointed tool.

All these operations would be the natural outcome of natural necessity; and it therefore follows that to seek with comparative certainty for traces of early man, the following conditions must be, as a rule, fulfilled: 1. Occupation sites, more or less permanent, are to be looked for near the older roadways leading to fords or ancient bridges, their outline being, though now marked by hedgerows, as devious and winding as the ancient track was. 2. Sheltered spots near these roads, protected from view by trees, and comparatively dry though still close to water (especially if the sites be likely to afford food supplies of roots or rabbits) are necessary. 3. The ancient names of places are often a valuable guide. All old camping-grounds being near water, the different equivalents for water in local names may

point to their position. As the Rev. Charles Kerry has stated, the names for or appertaining to liquids, are themselves liquid. Water, Ooze, Ouse (a river) Oasis, Well, Wet, all have *u*, *o*, or *w* as their prefix. Even the Saxon Wan has the same liquid sound. Thus Wanborough, "the hill by the marsh"; Wishmoor, the Uisk-moor, the water-moor or possibly the big drinking water (Celtic); and similar names would indicate, as they generally do, probable camping-grounds.

It does not follow that, whenever these three conditions are fulfilled, flint flakes, or occupation signs, will be as a matter of course discovered, any more than, when an excellent site for building is pointed out, one invariably expects to find a house there.

All that can be said is, that flakes, &c., are never found in places that do not fulfil these conditions more or less. Take the neighbourhood of Aldershot, for example. Near the Staff College by the "Wishmoor" stream, sheltered by the Easthampstead ridges, near the old tracks still existent, converging on the rare fords of the river Blackwater, was a definite "station." Lower down the rivulet, on a dry sandy peninsula, once washed on two sides by its waters, was another equally clear—not *on* the road, but *off* it; not in the way of enemies, but concealed from them by trees or hills.

On both sides of the Hog's Back, about Guildford, at the outcome of the streams, close to the ancient villages of Seale, Farnham, Puttenham, and the old manor of "Wanborough," the traces of early peoples lie thick in the flint flakes and tools that extend over certain limited areas there. Even the soil in these same areas is darker from occupation, and Mr. Kerry has found this sudden local alteration of colour to be a nearly infallible indication of primæval camps.

At Bob's Mount, near Reading, on dry land overlooking the erstwhile marshy valley of the Kennet, seemed a probable site, being near water, and having a corrupted ancient name. Search at once revealed numerous flakes and cores. Excavation at one point resulted in the exhuming of a Roman amphora. It had been for generations evidently an ancient halting-place. At Odiham, as will be seen by a glance at the map, are the springs and sources of one of the tributaries of the Loddon: near it is the village of "Wanborough," and the relics of a mediæval castle. Of course there were implements and flakes there, for everything pointed to old occupation. A main road to Basingstoke, an ancient name, abundant water springs. Primitive man had used it; Saxons had left their traces there; the Normans had seen its value, and had built a keep that checked the army of the Dauphin of France, and held prisoner the Bruce.

But what have the ancient people left behind them in these

places? They are indicated in Pl. IX. First and foremost are the cores from which the flakes have been struck. These are vertical, merely for making flakes; pyramidal for the same purpose or to be used as wedges and even rough heavy scrapers; some of the former pattern seem to have been definitely fashioned for smoothing down stakes for stockades or spear-shafts, the ends of which may have been previously charred by fire. The ends are left round so as to be held in the hand, or pointed to fit into a socket, but the other extremity is, as Dr. Gillespie first noticed, again broken across by a sharp blow at an almost constant angle, and the edge here bears marks of wear. In his paper read before the Anthropological Institute he says that in this form, commonly known as the "hoof core," the angle was exceedingly constant at 70°. "Out of the 100 cores which I examined 12 were double-ended, 35 were bevelled at an angle of 70° as near as possible, 10 at 75°, 24 at 80°, 9 at 65°, 5 at 60°." Thus cores for flakes, and "hoof cores" for tools, are always to be found. Then there are the flakes themselves. These are generally triangular in section, often rhomboidal. The sides bear marks of wear; the ends are often rounded as "thumb scrapers" to dress skins, pointed for boring holes, or to be used as rimers, or notched for finishing bone needles or completing arrow and spear shafts. But there are numerous fragments too. Some are rough bits knocked off in getting the flat table-end to a block of flint, whence long flakes were to be knapped. Others dressed roughly on all sides, without apparent intention, except to render them somewhat circular, may have been "throw stones," or sling stones. But a most common type of all is the "briquet," or "strike-a-light." They can be recognised at once by their similarity of shape, and by the equally similar marks of wear to those on the ordinary smoker's stone of his flint and steel. Rough sometimes on all sides but one; but on that the edge is chipped into a rounded form, on which there is much minute scalloping. They are thicker than the ordinary flake, are smaller generally, are roughly round, oval, or square, but always with one flat side and one even edge. Lastly there is the implement itself, the stone-chipped celt. These are naturally of a higher degree of art. They have not, as a rule, been made in the place where they were found, but have been brought there by their former owners, as the nature and character of the flint will tell. But they, like all tools, have worn by use. Repointing his axe by the evening fire, primitive man has often made a false stroke and broken or damaged his stone weapon. If in his opinion useless it was thrown aside like a broken knife, so that the axes found in these places are always well worn and damaged by an attempt at repair. It is the same with the arrow-heads. They are much used, and having lost their sharp-

ness and point are too small to re-chip. The useless barb, like a broken needle, was thrown aside. All these things may be expected, and most are found on the sites of the "surface finds."

Now they are rarely discovered in any number, strangely enough, in the old earthen entrenchments, or so-called Cæsar's Camps," of southern England, and there seems to be a sufficient reason for it. These occupy lofty sites, good posts of vantage for defence and observation, but the water supply must be faulty; the exposure is certainly unquestionable.

Fancy Archaic man, shivering in his coat of skins, on the top of one of these fortified hills, with the bottom of the neighbouring valley to go to for a draught of water.

These great entrenchments, which are certainly not Roman, and may well be deemed prehistoric, would have a much greater *raison d'être* if we imagine them to be the keeps or citadels of the neighbouring villages, to which, as in feudal times, all could go, flocks and herds, women and children, when danger threatened. Flakes would be rare there, then. There would be little time for peaceful amusements. The camp fire would be surrounded by anxious faces, too interested in outside matters to indulge in play.

Most of them are places of temporary, not permanent, occupation, and hence it is that relics are rare; for few of the entrenchments have good water-supply, and flocks, herds, and people would soon exhaust it, and render a speedy return to the watercourses absolutely necessary. The tribes did not live there, but only took temporary shelter, and this need have been brief, for even the assailants must disperse in search of food, and in all probability if the first attack failed they withdrew.

Where the fortifications surrounded actual village sites the conditions would be different, and the usual discoveries might be made; but the camps on lofty hills could not have been as a rule held for a lengthened period. The quantity of implements found in the Cisbury Camp need offer no exception to the rule, for the entrenchments were built on the pre-existing site of old quarries where flint had been dug for tools.

No traces can be found in surface-finds of actual dwellings, nor of the exact way in which the tools were held or hafted. But some ancient weapons have been found in other places with the old handle still fixed to them. Modern savage life again furnishes another clue. They were generally inserted in a cleft stick, sometimes vertically as a spear, at others in a curved branch, like an adze or pick. Doubtless withes, or strips of skins—the latter especially, as if tied wet they would shrink and tighten up the tool—were commonly used, and even in modern weapons there is an indication that such was really the case. Malay

creases often have in the metal at the base of the blade the mark or cast of the cord which fastened earlier weapons to the handle. What was once a necessity has become merely an ornament, and the survival of the idea is all that is left of the more ancient plan. Powerful weapons they were in the hands of a strong man. Heavy blows could be struck for offence and defence. From the Lincolnshire Fens came the skull of an ancient Bos pierced through the frontal bone by the stone axe of primitive man.

It is not difficult to distinguish between the true marks of wear and those produced by accident; nor need the chance fracture of a stone into a shape resembling the true relics be confused with the ancient tool. All real flakes, struck with intent, have one flat side marked by a rounded bulb at the end, the other sides being more or less numerous, though as a rule the section is triangular. When these have been used for scraping, either from right to left, or *vice versa*, the natural tendency of the operation would be to break off small fragments on one side of the used edge, leaving the other still unchipped. Accidental crushing would certainly be likely to create fine chipping or shelling on both sides of it. Intentional work rarely can leave traces on more than one side.

So with the implements. A true edge to a tool fashioned from material that breaks with a conchoidal fracture could only be produced by blows struck alternately on either side, thus forming a series of alternate scallops, giving a wavy edge. If the concavities were opposite to one another, as they generally are in accidental forms, and in by far the greater number of forgeries, a blunt crushed edge, incapable of cutting, would alone be made. All true flint workers, and notoriously those of old time, have recognized this. Nature's processes rarely conduce to a similar result; her work is nearly always irregular, but man's labours are characterized by regularity, and have a definite intention about them.

Nature, the grand instructress, will furnish a handful of useful though inferior tools from any gravel-heap or pile of *débris*. She can make implements, and make them very badly, too. No two of them are alike. None quite the thing. Human art and thought can alone produce similarity of workmanship. Nature may clumsily provide stones that could be used as weapons, but she does not make many, and even they are clumsy. Nature can fashion, or wear, or weather a rough rock pinnacle into the feeble semblance of a human face or form. Human art and intellect can see in and produce from the living rock the noble statue, or the speaking bust. Nature never shows us two flowers exactly alike. Art can give facsimiles of any given type of human handiwork, for in the results of man's skill there

is always a definite similarity. Old sub-angular flints and tools, again, have a well-defined lustre or patina due to alteration of the surface, and this peculiar appearance is difficult, if not impossible, to produce. Given, therefore, a stone shaped by bold chipping into an axe-like shape, with a wavy edge, shining with a tint unlike that of a freshly-broken stone among the relics of a surface-find, and it may be classed undoubtedly as a human tool.

But what, it is often asked, is the use of a study the materials for which are rare, the deductions from them so problematical? Now nothing could be more injudicious than to attempt to gauge the value of any knowledge by the results of the work done in one generation. Human life is too short for men to do more than further little by little the work of the preceding time, regardless, as a rule, whether their contribution to knowledge is worth preserving or not. Posterity will be the best judge of that. The philosopher who first applied two different pieces of metal to the leg of a frog and noticed that the muscles moved, scarcely foresaw that from that insignificant experiment would come the science of electricity and the shilling telegraph. When James Watt, pressing the lid of his aunt's teapot, found that steam had lifting power, he probably did not dream that from the development of the fact would come steam-ships that would move against wind and tide, and railways with engines that could travel at the rate of sixty miles an hour.

The old alchemists who, in their search after an imaginary philosopher's stone, discovered many a previously unknown chemical combination, many a hidden secret of nature's laboratory, did not imagine that the practical result of labour they then regarded as useless would be a better system of medicine, a more extended usefulness in the arts.

They worked for their own time, satisfied to do the work that pleased them best well, and left to future generations to accept what was good and reject what was bad in it. So with this study, one yet in its infancy even now. The most interesting study of mankind is man. All history is useful as teaching us lessons of what has gone before. Here we have traces of very ancient history indeed. Weak as the traces are they tell something of man's early habits before written records took the place of stone.

Then, again, even the value of a study should not always be measured even by its practical usefulness. In that charming book which all boys either have, or should have, read, "Evenings at Home," there is a story entitled "Eyes and no Eyes." It tells how two lads went in different directions for a walk and one returned with body exercised, it is true, but with mind unrested by the only rest mind can have—change of

thought; the other has seen the beauty of the flowers, the habits of the birds, the great glorious picture that grand old Nature opens to those who love her. Which is best or even most practical? To have a pursuit, even if it be but the study of flint chips, or have no other resource than that dreariest of all dull things, a mere "constitutional" walk. Average eyes by research and examination become comparatively microscopic in their power, and in seeking or searching for analogy between flint tools we may learn to understand better the shape and form and usefulness of other things too. Eye-training is mind-training also, for they must work together; and our woods and barren hill-tops, our valleys and plains have a fresh interest and a fresh light thrown on them if there can be found traces of human occupation to show that others, too, had loved them, others too, had seen their beauty before Greek or Roman had got beyond the age of Neolithic man. "The mind like a knife quickly rusts if not used. Unless the eye is trained to see, it becomes dim; unless the ear is trained to hear, it gets dulled; and this is why so many, careless to sharpen their wits on the whetstone of outlook and thought, enter into life and pass away from it, never knowing in what a world of beauty, bounty, and wonder they have lived."

Lastly one study so leads to another. An examination of the surface of the ground would lead most people to wonder what there was beneath it. The stone axe driven firmly into the head of a *Bos primigenius*, such as was found in the Lincoln Fens, must direct attention to the question of how the skull was deposited where it was found, and what were the physical conditions of the world in old time. Prehistoric archæology and geology are so closely allied as to be in some cases inseparable. Is geology of no importance? Can any knowledge of this grand universe around be considered valueless? What is good and vital and useful in any study will live; what is of no value will pass away like last year's flowers, which, useless as they seemingly were, gave pleasure and interest to some in their brief existence. Longfellow once wrote of a man of great scientific knowledge and repute—

Nature, the old nurse, took
The child upon her knee,
Saying, "Here is a story-book
Thy father has written for thee."

"Come wander with me," she said,
Into regions yet untrod,
And read what is still unread
In the manuscripts of God."

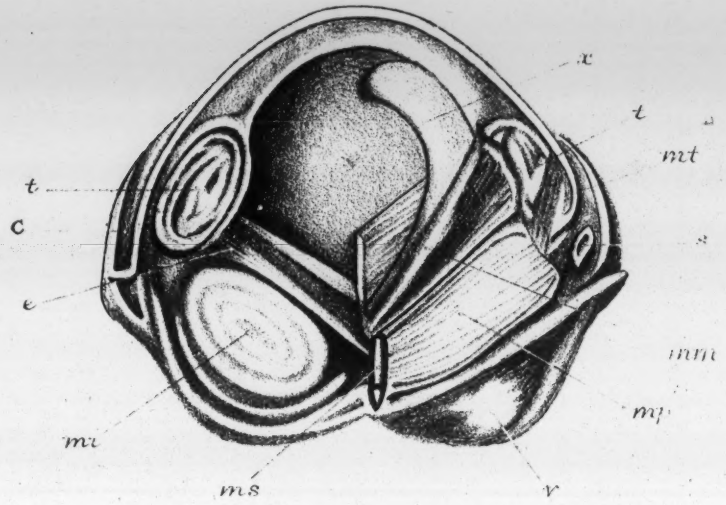
And he wandered away and away
With Nature, the dear old nurse,
Who sang to him night and day
The rhymes of the universe.

And whenever the way seemed long,
Or his heart began to fail,
She would sing a more wonderful song,
Or tell a more marvellous tale.

EXPLANATION OF PLATE IX.

The plate is designed to show the set of things that may always, or nearly always, be collected at the temporary halting-places of early races of mankind. They consist of implements (*a*) with a true wavy, and therefore cutting edge, very different from the similarly shaped stone (*b*) which has a crushed edge, and is therefore either a forgery or has been the result of accidental and not intentional shaping. The flakes (*c*) may either be triangular or rhomboidal in section, and, like these two, unworn, having been merely knocked off in fashioning a tool. But they may on the other hand have been used for work, and then the marks of true wear (*d*) will be distinguished from the "crush" wear (*e*) by being on one side of the edge rather than on both. The cores may be of different shapes (as *f*, *g*, *h*, *i*), while those with lower angles, produced as in the "hoof" cores (*h*), or (*i*) by striking off a fragment of flint after the core has been made roughly cylindrical, frequently bear marks of wear as if they had been employed as rough chisels. The briquets (*k*), or strike-a-lights, are thick oval pieces of flint, with one edge worked somewhat round, and one side nearly flat. It is on this, that the material used as tinder is held. Some of the irregular pieces (*l*) have a rough cutting edge on one side only, the other being left round so as to be held in the hand, while many flakes are worked for special purposes, such as long "thumb scrapers" for skin-dressing (*m*), notched scrapers (*n*) for arrow-fashioning, piercers or rimers (*o*) for making the eyes in bone needles, and circular scrapers (*p*), which are large oval pieces of flint much thinner than a briquet, but bearing marks of wear all round. There is not much difference between these two forms, save that the scraper being thinner is better calculated for the work.

1



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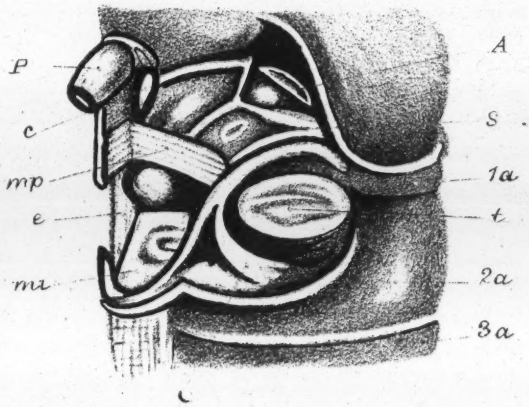

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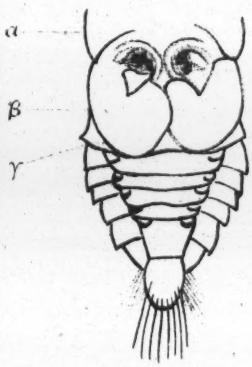

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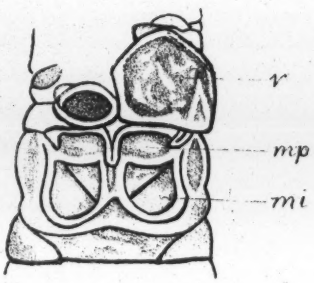

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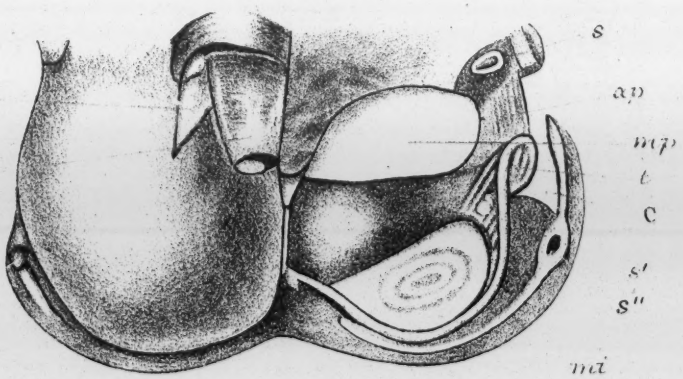


J. C. Bidlon del.

W. West & Co. lith.

Vocal Apparatus of Cicada.

THE SONG OF THE CICADA.

By JOHN C. GALTON, M.A., F.L.S.

[PLATE X.]

"Süssen Frühlings süsser Bote!
Ja, dich lieben alle Musen,
Phöbus selber muss dich lieben,
Gaben dir die Silberstimme."—GOETHE. From *Anacreon.*

"The Cicada, people of the pine,
Making their summer life one ceaseless song."—BYRON.

THE song of the Cicada * has been familiar to man from the most ancient times. Among the Greeks this insect was the object of a veritable "cultus," and for the enjoyment of its song it was imprisoned in a cage, just as are the song-birds of more modern times.† A Cicada sitting upon a harp was the emblem of the science of music; for the story goes that when the two rival musicians Eunomus and Ariston were contending upon the harp for a prize, a Cicada, flying to the former and perching upon his instrument, supplied by its voice the place of a broken string, and thus secured to him the victory.‡ Anacreon

* The Latin name *cicada* is derived, according to Beckmann, from the word *cicum* or *ciccum*, "a thin skin," and ᾄδειν, signifying a sound produced by the motion of a pellicle. Others derive it from the Latin words *cito cadat*, implying that the insect soon vanishes, is short-lived. Westwood's "Classification of Insects," Vol. ii. p. 421.

† Such is still the custom in China. This can hardly, however, be accepted as a criterion of musical taste.

‡ "Kirby and Spence's Entomology," Vol. ii. p. 403. Winckelmann, however, the celebrated German art critic, makes the statement ("Versuch einer Allegorie," Werke, Band II. s. 529), that an indifferent bard was symbolized by a Cicada. This, however, he appears further on (Ibid. s. 548) to contradict by saying that Music is represented upon coins of the Messenians in Arcadia, where, according to the testimony of Polybius, it was practised more than among all the Greeks, by the same insect. In an editorial foot-

has dedicated to this insect one of his most charming odes.* He there exalts its melodious voice, reverences it as the sweet harbinger of summer, calls it the "friend of the Muses," and, finally, places it in the rank of the gods.

The Latins were far from sharing in this Greek enthusiasm, for Virgil † accuses it of bursting the bushes with its harsh and deafening song:

Et cantu querulæ rumpent arbusta Cicadæ.

In the South of France its song is held in but slight esteem. As for the northern provinces, they do not even know it, for they mistake for its music the cry of the large green grasshopper. This error has been committed by the great French fabulist La Fontaine, who speaks of the Cigale as chanting *all the summer, day and night.* The artist, moreover, has drawn a grasshopper to illustrate the first fable of this celebrated humourist.

Leaving now the domain of imagination and poetry for that of prosaic fact, we will direct our attention to the mechanism of the cry of the Cicada, be this regarded as musical or the reverse. Aristotle knew that the musical organ of this insect lay in the abdomen, and that it was, moreover, peculiar to the male sex.‡ The latter fact, too, was familiar to the poet Xenarchus of Rhodes, for he sang, in not very gallant strain:

Happy the Cicadas' lives,
Since they all have voiceless wives.§

But to the naturalist Réaumur must be conceded the honour of discovering the sound-producing organ, the drum—"la timbale."‖ Unfortunately, this illustrious observer was not able to dissect living Cicadæ, and his attention—directed to a funda-

note to the first-quoted passage, it is further stated that upon a vase of baked earth in the rich collection of the family Vivenzio, in Nola, there is the humorous representation of a poet placing in the flickering flame of an altar his lyre, from the strings of which some Cicadæ are springing.

"According to Plato the Muses transformed into Cicadæ the men who amused themselves by singing, and were so absorbed in that occupation they forgot to eat and to drink." De Gubernatis, "Zoological Mythology," vol. ii. p. 223. London, 1872.

* Ode LXIII: "Εἰς τέττιγα." This has been beautifully rendered by Goethe.

† Georg. III. 328.

‡ "Οἱ τέττιγες. Πάντα δὲ ταῦτα ψοφεῖ τῷ ὑμένι τῷ ὑπὸ τὸ ὑπόζωμα, ὅσων διῄρηται, οἷον τῶν τεττίγων τι γένος τῇ τρίψει τοῦ πνεύματος." "De Animalium Historia," Lib. IV. cap. 9, § 3.

§ The original, which is from a fragment—ΥΠΝΟΣ—is as follows:—

Εἶτ' εἰσὶν οἱ τέττιγες οὐκ εὐδαίμονες,
ὧν ταῖς γυναιξὶν οὐδ' ὁτιοῦν φωνῆς ἔνι.

‖ "Mémoires pour servir à l'histoire des Insectes," Tome V., Pl. XVII. 1740.

mental point—was not sufficiently called to accessory parts. Carus inquired into the connection of the apparatus of song with that of respiration.* He shows that the interior of the abdomen forms a considerable air-chamber, and records the discovery of a pair of stigmata which enable that cavity to communicate with the exterior. Colonel Goureau, in an essay upon Stridulation,† only just touched upon the subject; but his memoir was completed in the same year by M. Solier.‡ Dugès § announced the existence of the tensor muscle of the drum, but M. Carlet—Professor in the Faculty of Sciences at Grenoble—the author of a very recent memoir ‖ to which we are indebted for the main facts embodied in this article, has searched for it in vain, and hopes to demonstrate conclusively that it has no existence. Doyère, in the Crochard edition of the "Règne Animal" of Cuvier, gives figures of the vocal apparatus; but they are incomplete, and the magnifying power is not sufficient to show the details.¶ Besides this, they only represent the exterior of the musical organ. M. Carlet has recently contributed two notes to the "Comptes Rendus," ** one upon the stigmata of the Cicada, the other upon a muscle of the musical apparatus, described under the name of *tensor of the folded membrane* ("membrane plissée"), which will be studied in detail further on.

As regards the question whether the sound produced by the Cicada can be properly termed its *voice* or not, Aristotle laid down the principle that those animals alone which respire can be said to have a voice; and as he believed that insects did not respire, they, according to him, only produce *sounds*.†† Réaumur states, on his side: "If we give the name of voice only to the kind of sound produced by air driven out of the lungs, and which, on its exit from the larynx, is modified by the glottis, insects have no voice. But if we believe it to be necessary to

* *Ueber die Stimmwerkzeuge der italiänischen Cicaden.* "Analekten zur Naturwissenschaft und Heilkunde," 1829.

† *Essai sur la Stridulation des Insectes.* "Annales de la Société Entomologique de France," Tome VI., 1837.

‡ *Observations sur quelques particularités de la Stridulation des Insectes, et en particulier sur le Chant de la Cigale.* Ibid.

§ "Traité de Physiologie comparée," Tome II. 1838.

‖ *Sur l'Appareil musical de la Cigale.* "Annales des Sciences Naturelles," 6ième série, Zoologie, Tome V.

¶ Insecta. Pl. xlv., figs. 2*c*, 2*f*; figs. 4 and 5 of the plate illustrating this article.

** *Sur l'Appareil musical de la Cigale.* "Comptes Rendus de l'Académie des Sciences," 1876.

†† "Φωνεῖ μὲν οὖν οὐδενὶ τῶν ἄλλων μορίων οὐδὲν πλὴν τῷ φάρυγγι· διὸ ὅσα μὴ ἔχει πνεύμονα, οὐδὲ φθέγγεται." "De Animalium Historia," Lib. IV., cap. 9, § 1.

give more extension to this term, if we agree that all the noises ('bruits'), that all the sounds ('sons'), by means of which animals induce those of their species to perform certain actions deserve the name of voice, then we shall find as regards voice among insects and the organs of that of the Cigale, that they will be well worthy of our admiration."

Dugès proposed the word "stridulation," which has since become classical, to designate the sound caused by the vibration of solid plates; but he reserved the name of "voice" for that produced in a larynx by means of expired air. But in these days it has been fully demonstrated that in the act of *phonation* it is the vocal chords which form the vibrating body, while the current of air is simply the motor element; the cavities of the pharynx and the thorax acting as a veritable sounding-box. All these elements, then, are to be found in the musical apparatus of the Cicada, the vibrating body being there represented by the "timbales," the motor agent by the muscles of the "timbales," and the sounding board by the cavities of the thorax and abdomen. In both cases, then, it is a vibrating membrane which produces the sound; the sole difference being in the fact that, on the one hand, this membrane is set in motion by a current of air, while, on the other, it is put in vibration by a motor muscle. From this it follows that there will be no incongruity in preserving the name *song* to indicate the vocal manifestations of the Cicada, although, scientifically speaking, the term *stridulation* would be preferable. In the neighbourhood of Grenoble the Cicadæ usually sing from the season of the flowering of the vine until the second week in August.* The *Cicada hæmatodes* is the first to appear, but does not sing much longer than the middle of July, when the *C. plebeia* begins to be heard, thus soon completely replacing the former. It is only during the day that the Cicada sings, and almost only during the sunshine —"sole sub ardente," as Virgil sang.† The large green grasshopper, which is often erroneously taken for the Cicada, on the contrary, makes itself heard during the night; and its *zic, zic,*

* The parallel of the forty-fifth degree of North latitude, on which the town of Grenoble lies, is a northern limit which the Cicadæ scarcely transgress in France. Nevertheless, they are to be heard a little, in all years, in the vineyards of Burgundy, and some specimens may even be taken in the neighbourhood of Fontainebleau. Pliny states that the voice of the Cicada is loudest at the solstices—'circa solstitium.'—Nat. Hist. Lib. XI. 107.

† "The cicada is supposed by some to pipe only during mid-day, but both in Central America and Brazil I found them loudest toward sunset, keeping up their shrill music until it is taken up by night-vocal crickets and locusts."—Belt, "The Naturalist in Nicaragua," p. 312. London. 1874.

zic quite differs from the stridulation of the Cicada, which can be represented sufficiently correctly thus:

*dzsss - - - - - - - - ssssst.**

When the Cicada sings in a state of freedom, it keeps rapidly moving its abdomen, depressing and raising it in turns, so as to approximate or separate the *opercula* ("volets"); of which organs more anon. During this period the wings are motionless and applied close to the body. But if the insect be in captivity, in a cage for example, the abdomen does not habitually show any movements during the song. Lastly, if one holds a Cicada between the fingers, it violently vibrates its wings and sets in motion all the free part of its body, uttering piercing cries which sensibly differ from its ordinary song; but soon the cries cease, and the wings droop immovable with fatigue.

Before proceeding to describe the special structure of the sound-producing organs of the Cicada, it may be as well first to state, for the information of readers who are not zoologists, that all members of the group *Insecta*, to which the Cicada belongs, have the body primarily divided into "head," "thorax," and "abdomen." These parts are further differentiated into rings, segments, or "somites,"† of which the head usually has six, fused together, the thorax consisting of three, distinct and furnished with limbs, while the abdomen is made up of from seven to eleven, usually nine, "somites," all limbless in the adult insect.‡ In nearly all perfect insects each ring of the thorax carries on its under side two pairs of legs; and on the sides of the two hindermost rings (the "meso-" and "meta-thorax") two pairs of wings or their representative organs. Our attention, however, need only be specially directed to the last "somite" of the thorax and the first two of the abdomen in the Cicada. All descriptions hitherto given by authors of the musical organs of the Cicada are copied from Réaumur, and, inasmuch as they are incomplete and inexact, fail in clearness. The following description of them will be founded upon the record of the researches of M. Carlet, to which reference has been already made.

* "Added to these noises were the songs of strange cicadas, one large kind perched high on the trees around our little haven, setting up a most piercing chirp; it began with the usual harsh jarring tone of its tribe, but this gradually and rapidly became shriller until it ended in a long and loud note, resembling the steam-whistle of a locomotive engine."—Bates, "The Naturalist on the River Amazon," p. 230. 3rd edition. London. 1873.

† From the Greek word σῶμα, "a body."

‡ The sole exception is a beetle (*Spirachtha eurymedusa*), whose third, fourth, and fifth abdominal somites carry two-jointed limbs.—Vide Professor Macalister's "Introduction to Animal Morphology," . 386, Lond. 1876.

The Cicadæ, which are the subject of M. Carlet's memoir, were principally *Cicada plebeia* and *C. hæmatodes*, and were found in the environs of Grenoble. As many vivisections were made, his observations must be more searching than those of Réaumur, who only examined dry specimens or those preserved in alcohol. *C. orni* and *C. maculata* have also been dissected in the dry state. *C. plebeia* is, however, regarded by M. Carlet as the type of the genus and as the "classical Cigale."

For description, the body of the insect will be supposed to be placed vertically, the head being above and the belly directed forwards.

M. Carlet, for the sake of clearness, divides his description into an anatomical and a physiological section. Under the former category are comprised:—

1. The Framework ("charpente") of the Vocal Apparatus.
2. The Vibrating Membranes.
3. The Muscles in relation with the above.
4. The Sonorous Cavities.
5. The "Stigmata," or orifices of communication of these cavities with the exterior.

A. *The Framework of the Vocal Apparatus.*—This includes the last "somite" of the thorax (*metathorax*) and the five or six first segments of the abdomen.

1. The *Metathorax.*—On the lower border of this "somite," in front of and between the "peritrema" (a horny circle surrounding the opening of a stigma, *s*, figs. 1, 2, 3), may be seen a small chitinous * point, of which more anon, termed the apophysis of the folded membrane ("membrane plissée" *ap*, fig. 3.) The metathoracic segment is roofed in by a partition (*entothorax*) made up of two wing-like branches, having between them a mesial slit. The most salient part, however, of this somite is the organ called "volet" † by Réaumur, and otherwise known by the name of *operculum* ‡ (*v*, figs. 1 and 3). This is nothing more than a prolongation of the *epimeron*,§ and is not movable, as Réaumur believed. It is greatly developed in *C. plebeia*, and has the shape of a semicircular scale of which the rounded edge descends as far as the second ring of the abdomen. It is necessary to raise it on either side in order to bring the anterior part of the musical apparatus into view. In female Cicadæ these structures are rudimentary, and do not

* *Chitine* is a horny substance, insoluble in caustic potash, of which almost all the hard parts of insects consist.

† French, "a shutter." ‡ Latin, "a lid."

§ One of the twopaired lateral elements of the *pectus* or lower half of a thoracic "somite."

sensibly differ from the *epimera* of the other thoracic segments.

At the upper and internal angle of the epimeron of either side is to be seen the first joint (*coxa* "hanche," P. figs. 1, 2, 3,) of the leg of the third pair. It is accompanied by an appendage called "cheville" (*c*, figs. 1, 2), by Réaumur, which is none other than the *trochanter* of the thigh which has taken on a great development, and is received, in part, into a slight depression in the *operculum*. This arrangement led Réaumur to believe that the *trochanter* acted as a check to prevent the *operculum* from moving too much—an error, as the latter is quite immovable.

2. The first abdominal segment. This may be conveniently divided into a peripheral, and a central part.

a. The peripheral part. This "somite" is narrow behind, and forms on its sides the upper border of the frame of the drum ("cadre de la timbale"). This border divides in front into two branches, which eventually form two ridges ("arêtes") of a triangular pyramid, termed by M. Carlet the "tetrahedron," which has its apex at their point of divergence. There are, moreover, four sides, or faces, of which one forms the base of the tetrahedron, while that which is bounded by the anterior and posterior ridges is pierced for the first stigmatic orifice (*s*, fig. 1) of the abdomen. There are two symmetrical tetrahedra.

b. The central part, which comprises the *entogastrium* (Audouin, *op. cit.* p. 125), or "triangle écailleux" of Réaumur. M. Carlet proposes to retain the first term, as a reminder that the part is homologous with the entothorax. The entogastrium somewhat resembles a bird with a forked tail and wings spread out. A median crest is developed upon the hinder part of its body, affording insertion for the motor muscles of the "timbales" (fig. 1).

The second segment of the abdomen is very broad behind and on the sides (2*a*, fig. 2), but becomes much narrower in front (2*a*, fig. 3), clasping by its concavity the preceding somite, with which it becomes completely fused in the middle line. This arrangement is exactly the reverse of that of the first segment, but is to be found only in the male insect. Laterally there will be found in the second segment a kind of inclined plane, resting upon its upper margin, which M. Carlet terms the floor of the cavern ("plancher de la caverne"), as it forms the lower surface of this cavity (C, figs. 2, 3). A large chitinous scale ("apophysis of the cavern," *ap*, figs. 1, 3), is to be seen at the junction of the part just described with the second abdominal ring, which forms the outer wall of the cavern. It is triangular, completely masking the drum, to see which it must be lifted, and is itself in turn covered by the lower (or hinder) wing, when this is at

rest. The other abdominal segments, which help to make up the lower part of the framework of the musical organ, present nothing worthy of note, except that each has a stigma on the ventral surface.

B. *Vibrating Membranes.*—The principal are the three following: the *drum* ("timbale,") the *mirror* ("miroir,") and the *folded membrane* ("membrane plissée,"), and are all situated in pairs on either side of the median plane.

1. The *drum* ("timbale" of Réaumur) (*t*, figs. 1, 2, 3), sometimes also termed "tympan," is translucid, and is imbedded in a rim ("cadre,") from which it projects into a hollow called the *cavern*. In coincidence with its rim the circumference is elliptical. Of its surfaces the outer one is convex (*t*, fig. 2), and is furnished with five or six chitinous arches, while the inner surface is concave. At the hinder point of junction of the arches is a thickened spot where the tendon of the motor muscles of the drum is inserted (fig. 1). The membrane itself is composed of an epidermic tissue made up of lozenge-shaped cells. In females the drum is represented by a chitinous scale imbedded in a rudimentary tympanic rim.

2. The *mirror.*—The membrane so named by Réaumur is stretched between the lower borders of the wing of the *entogastrium*, the base of the internal surface of the *tetrahedron* and the ventral part of the first abdominal somite (*mi*, figs. 1, 2, 3). It is in the form of a semicircle, of which the diameter is the internal edge of the *wing* of the *entogastrium*, (vide fig. 1). It is a flat and diaphanous plate of extreme thinness, having in its middle iridescent rings. Microscopically it is made up of a layer of lozenge-shaped cells, like those of the drum, but much more delicate. The two mirrors are separated in the middle line by the *body* of the *entogastrium* (vide fig. 2). They are, lastly, rudimentary in the female insect.

3. The *folded membrane* ("membrane plissée," *m p*, figs. 1, 2, 3).—This organ is soft in the fresh state, and transversely folded in repose, whence the name given to it by Réaumur. By its laxity it differs from the drum and the mirror, which are always dry, *ergo*, more or less tense, membranes. It is, moreover, opaque, while the first named is translucid and the latter diaphanous. It has the form of a rectangle, of which the two surfaces are directed anteriorly and posteriorly. The membrane itself is composed of two layers, one superficial, of elastic fibres, the other deep, of the nature of a lining membrane. The elastic fibres lie parallel and are folded zigzag-wise. It is, like the preceding organs, rudimentary in the female Cicada.

C. *The Muscles.*—There are three pairs, of which only one has been previously described by naturalists. They are symmetrical, two and two, and are absent in the female.

1. *The motor muscle of the drum* (*m m*, fig. 1).—This is the most important. Réaumur, who discovered it, gave it no particular name, but M. Solier termed it "the musical muscle." This name should be abandoned, as it shares the music-producing function with two other sets of muscles. According to Dugès (*op. cit.* Tom. ii. p. 228), another muscle of the drum—"très-petit, caché sous le bord inférieur du cadre de la timbale qui l'a dérobé aux anatomistes, a pour usage peut-être d'augmenter la tension de la timbale." M. Carlet, however, does not believe in its existence, and promises to demonstrate that, even were it present, it would completely spoil the action of the musical apparatus. The tensor of the drum is the most bulky muscle in the Cicada's body. It takes its *fixed* origin from the whole extent of the entogastric crest; whence its fibres pass outwards and backwards to abut upon a disk, from which there proceeds a short tendon to a *movable* point of insertion upon the drum. At the junction of the two trunks of this muscular cone is to be seen a membrane which assumes the form of a half-ring (*x*, fig. 1). This goes horizontally to be inserted upon the *tergum** at the junction of the first two abdominal somites, only leaving between itself and this part just space enough for the passage of the dorsal vessel. In conjunction with its fellow this membrane forms an oval ring, allowing of communication between the cavities of the thorax and abdomen. The fibres of the tensor of the drum are of the *striped* kind, and are inserted into an elliptical disk ("plaque cartilagineuse" of Réaumur), from which the triangular tendon arises, to be attached by a membranous tongue to the postero-inferior part of the rim of the drum.

2. *Tensor of the folded membrane.*—This muscle, which M. Carlet believes that he was the first to describe, is cylindrical in form (*m t*, fig. 1), and has its *fixed* origin from the upper border of the frame of the drum, while its insertion (*movable*) is at the posterior part of the apophysis of the folded membrane. It, too, belongs to the *striped* variety; and, as in the preceding muscle, between its fibres and the point of insertion there intervenes a conical disk carrying a very short tendon.

3. *The sterno-entogastric muscle* (*m s*, fig. 1).—This name is derived from the two points of origin and insertion. The muscle passes longitudinally from the apex of the entogastrium to a triangular projection springing from behind the upper point of the *sternum* of the metathorax. The fellow muscles lie very close to one another on the middle line, and communicate with the deep surface of the folded membrane.

D. *Sonorous Cavities.*—Under this general term are comprised

* The *tergum* is the upper or dorsal element, or factor, of a thoracic segment, the insect being placed upon its legs.

those cavities in the body of the Cicada which are filled with air, and where this ethereal fluid is thrown into waves by the vibrations of the drum. They are five in number—one median and four lateral.

1. The *thoraco-abdominal cavity*—the "grande cavité" of Réaumur, is formed by the junction of two (thoracic and abdominal) cavities. It comprises the internal cavity of the metathorax and the five or six first abdominal somites, and is roofed in by the entothoracic partition, which gives attachment to the muscles of the legs and wings of the metathorax, while below it terminates in a vast *cul-de-sac*, at the bottom of which the abdominal viscera are packed.

It is constricted at its middle by the "oval ring," mentioned above, which is stretched between the muscles of the drum (*x*, fig. 1); and reminds one of an hour-glass, of which the upper bulb would be the thoracic cavity, and the lower that of the abdomen.

2. The "*second cavern*" (Dugès), termed by Réaumur the "cellule" (C, figs. 1, 2, 3). Its entrance is concealed by the *operculum*, which must be lifted in order that it may be seen. The cavity itself is a *cul-de-sac*, of which the external wall is concave, and shows an opening in the shape of a narrow slit, which is covered by the *scutellum* * of the metathorax.

3. The *sub-opercular cavity* is a vast chamber covered by the *operculum*, bounded above and below by the folded membrane and the mirror respectively (fig. 3). It is completely closed in *C. plebeia* when the abdomen is lowered, but when this part of the body is raised it is open below and on the two sides. The two cavities are separated one from the other in the middle line by the body of the *entogastrium*.

E. *The Stigmata.*†—Their action, though but little studied as yet, is of the greatest importance. Léon Dufour‡ states that the Hemiptera — to which order the Cicada belongs — have generally but one pair of thoracic stigmata, and that those of the abdomen of the Cicada are six pairs in number; but M. Carlet has found that there are three pairs of thoracic stigmata (in both sexes) and seven pairs in the abdomen. The third and lowest pair in the thorax are to be found beneath the *operculum*, or *epimeron* of the metathorax (*s*, figs. 1, 2, 3). The first abdominal stigma (*s'*, fig. 3) will be seen on the internal

* In English, "little shield." It is one of the four elements of the *tergum*, or upper section, of a thoracic "somite."

† The air-holes which communicate with the *tracheæ*, or air-tubes, in Insects. The word is the plural of the Greek στίγμα, "a spot."

‡ Recherches anatomiques et physiologiques sur les Hemiptères." p. 257.

surface of the "tetrahedron," while the stigmata of the second pair (*s''*, fig. 3) are sometimes obliterated, and consequently less easily seen than the others.

The stigmata of the thorax differ from those of the abdomen not only by their position, but also by their shape and structure; the former being well developed, furnished with a horny rim (*peritrema* *), edged with hairs, and with a movable valve which opens and shuts like an eyelid, while the latter are mere punctures, devoid of the above accessories. The stigmata in connection with the sonorous cavities, to wit, those of the metathorax and the first of the abdominal pairs, claim special attention. The first named has a chitinous *peritrema*, and two eyelid-like valves, furnished with lashes, of which the lower alone is movable. In *C. plebeia* it debouches directly into the metathoracic cavity, but in *C. hæmatodes* communicates with a large air-vessel, which ramifies over the upper surface of the muscles of the drum.

The first stigma of the abdomen (*s'*, fig. 3), is situated in the internal surface of the "tetrahedron," a little above the mirror, and consists of a little round orifice, debouching into a tracheal trunk, which eventually breaks up into numerous branches.

The Mechanism of Stridulation.—In order rightly to understand its functions, it will be best to study separately the *rôle* of each of the factors of which it is made up.

It is a mistake to suppose that the framework of the vocal organ acts merely as a support and a guard for the vibrating elements. On the contrary, it is in itself an admirably arranged organ of vibration; it can, in fact, be said that the whole body of the Cicada vibrates when it is in song. For the *tergum* of the prothorax may be seen to tremble during the chant, and if the vibrations of other parts of the body are less obvious, they can at any rate be rendered apparent by putting them to the proof of touch. As regards the *rôle* of the membranes and their muscles, a distinction must be made between those which vibrate *directly*, and those which do so secondarily *by influence*. The former, or the drums, are put in motion by special muscles, while the latter—the mirrors and folded membrane, are excited by the vibrations of the drums. With regard to the drums—if these be removed while the insect is singing, the sound will immediately cease; but if they be left intact, while the others are removed, the song, though weakened, will continue to be heard. The drum is therefore the sound-producing organ, the vibrating body, which, throwing the air into waves, acts upon the neighbouring membrane. Réaumur discovered this fact by pulling the muscle of the drum in a dried specimen of the

* From the Greek περὶ, "around," and τρῆμα, "a hole."

Cicada. After having been excited by its motor muscle, the drum returns to its state of rest by virtue of its elasticity,* an effect aided by the chitinous bands. Some authors have stated that the drum becomes concave at the moment of the contraction of the motor muscle, but the real fact is that, with the exception of a very slight depression at the point of attachment of the tendon, the membrane constantly retains its convexity, and never yields, at all events, in adult insects. In young specimens, however, the drum, having less power of resistance, is rendered somewhat concave by the action of the muscle, and this peculiarity was utilized by M. Carlet to demonstrate the synchronism in the vibration of the drums. For if these be exposed, by cutting the wings of a young specimen of *C. hæmatodes*, they will be seen, during the song, to be at one and the same time both concave or both convex.

M. Solier, after carefully examining the muscle of the drum during song, was not, even by the aid of a lens, able to distinguish the slightest movement; but M. Carlet, on repeating the experiments, plainly observed a to-and-fro motion of the muscle, and concludes that M. Solier must have experimented on a Cicada already tired out. M. Carlet has further attempted to register the vibrations of the drum, and by the following method. A long needle of glass, drawn out to a thread in the flame of a spirit-lamp, was fixed at a tangent by means of a little wax to the exposed drum-membrane, and the insect, held by the end of its body, while in song, was made to trace the vibrations on smoked paper rolled round a cylinder rotating by clockwork, † simultaneously with tracings of a standard tuning-fork. By comparing the two sets of tracings thus obtained, the number of vibrations made in one second by the drum could be calculated. The numbers cannot be given by M. Carlet, because they are not constant. The captive Cicada, however, cries rather than sings, the musical sound being probably modified by the mutilation to which the insect is subjected, as well as the embarrassment caused by the wax on the drum and the friction of the glass index against the smoked paper. It has been stated some pages further back that there is no tensor muscle of the drum, and that if there were one, it would be a hindrance rather than a help. The reason is this—that the membrane,

* This is a good example of physiological economy. Similar instances may be found in the passive action of the costal cartilages in antagonism to the active contraction of the muscles which expand the chest in respiration, and in the elasticity of the hinge in passive opposition to the *adductor* muscle which closes the two valves of the shell in the oyster.

† An apparatus probably resembling the well-known arrangement of Professor Marey.

dry and parchment-like naturally, has no need of being put in tension. More than this, it is convex, and a tensor muscle would but hinder it from returning to its natural convexity; in other words, would act in opposition to its vibrations.

Membranes vibrating secondarily by influence. The mirror and the folded membrane. — Réaumur was aware that the mirrors served to reinforce the sound produced by the vibrations of the drums. Without doubt, too, they are useful in preventing the entrance of foreign bodies into the abdominal cavity, which would interfere with its power of resonance. The vibrations of the mirrors may be demonstrated by sprinkling fine dust over their surface, which will dance as soon as the song begins.

The folded membrane would seem, at first sight, to be but ill adapted for the reinforcement of sound, as it is lax and soft in the fresh state. Sufficient tension, however, is brought about by its special tensor muscle, which is, in turn, antagonized by the sterno-entogastric muscle. The former acts by drawing the apophysis, at the point where it has its *movable* insertion, outwards and backwards. The absence, moreover, of this muscle in the female insect is an indirect proof of its action, which can be distinctly shown by dividing it with a fine pair of scissors, when a diminution in the intensity of the sound will be perceived. As regards the sterno-entogastric muscle, its *rôle* is somewhat complex; but M. Carlet concludes, after elaborate experiments, that in its active condition, or that of contraction, it approximates the thorax to the abdomen, at the same time puckering the folded membrane; while in its passive state, or that of relaxation, it draws this membrane closer and renders it plane throughout its whole area, thus coming to the aid of the tensor muscle in facilitating its vibrations.

The Functions of the Sonorous Cavities and the Stigmata. —The thoraco-abdominal cavity differs from the others in that it alone is brought into communication with the outside by stigmata, while the other cavities communicate freely and directly with the exterior. The first-named cavity represents a drum with two membranes, of which the case is chitino-membranous, the function of the two skins being fulfilled by the "timbales." As for the *rôle* of the stigmata, it can be fairly likened to that of the opening of the Eustachian tube in the tympanic cavity of the organ of hearing, their office being to bring about equilibrium in tension between the external air and that confined in the cavity into which they lead. The difference in tension between the imprisoned air and that outside must certainly be at its maximum during the contractions of the motor muscles of the drum, because of the heat set free by their molecular action; and the eyelid-like stigmata are accordingly to be seen

opening and shutting by turns during the song of the Cicada. With regard to the caverns and the subopercular cavities—the former perform, in relation to the "timbales," the same *rôle* as do the subopercular cavities in relation to the mirrors and folded membranes. If the abdomen in a living Cicada be raised in such wise as to open the above cavities, the sound immediately increases in intensity, just as when the windows are opened in a room in which a musician plays, those outside can hear better. If, on the contrary, the abdomen of the same insect be depressed, so as to cause it to rest against the *opercula*, the sound becomes muffled; and the same effect is produced by the Cicada when free, by suddenly depressing its abdomen after it has been raised, and it is to such oscillations of the abdomen that the *accentuated* song of *C. plebeia* must be attributed.

About ten years ago, M. Landois, in a most valuable paper on the vocal organs of insects,* demonstrated that the "timbale" of Réaumur cannot act in the manner described above, since, instead of being movable by muscular action, it is firmly attached to the wall of the metathorax. "The song of the Cicada," he concludes, "is its voice. This is produced by the air from the trachea setting the vocal chords of the metathoracic stigma ('Schrillstigma') into vibration. The shell-like membrane in the chitine ring ['timbale'] and the delicate membranes at the bottom of the cavities ['folded membrane'] are merely an apparatus of resonance." Dr. Paul Mayer, as the result of some recent experiments made upon *Cicada orni*, in the Zoological Station at Naples, arrives at almost the same conclusions as M. Carlet." †

Touching a "schema" of the musical apparatus of the Cicada. After studying the mechanism of a *physiological* apparatus, we ought always, thinks M. Carlet, to have in our mind's eye the construction of a *physical* apparatus which, while reducing the first to its simplest expression, nevertheless reproduces the principal peculiarities of its action. A schema of the vocal organ of the Cicada is easily constructed. A little slip of metal is taken, having a groove on its inside edge, and bent in the form of the letter U. Into each groove a thin plate of steel is next fitted in such wise as to obtain two parallel springs, free for half of their length. Before introducing the two plates, there should be made in the centre of the outer surface of each a slight but permanent depression; and an instrument is finally obtained somewhat analogous to the ubiquitous toy recently

* *Die Ton-und Stimmapparate der Insecten in anatomisch-physiologischer und akustischer Beziehung.*—"Zeitschr für wissensch. Zoologie," bd. xvii. s. 105; and Taf. xi. figs. 17, 18. 1867.

† *Der Tonapparat der Cicaden.*—*Ibid.* bd. xxviii. s. 79. 1877.

brought out under the name of "Cri-cri." In order to make the model act, all that is necessary is to hold the frame of the instrument in the left hand, while with the thumb and forefinger of the right the free portion of the two steel springs is alternately and rapidly brought together and again let go; and, as the depression in the two plates thus becomes by turns convex and concave, a stridulation is produced which is a fair imitation of the sound of the Cicada. The drums are imitated by the depression in the steel springs, while the motor muscles of the former are represented by those of the left hand.

The musical apparatus of the male Cicada is classed by Mr. Darwin ("Descent of Man," vol. i., p. 350) as one of the "secondary sexual characters" among insects. *Apropos* of this he quotes (*op. cit. p.* 351) from a journal of Dr. Hartman, the following about *C. septemdecim* in the United States:—"The drums are now heard in all directions. This I believe to be the marital summons from the males. Standing in thick chestnut sprouts about as high as my head, where hundreds were around me, I observed the females coming around the drumming males." Fritz Müller, moreover, wrote to Mr. Darwin from S. Brazil that he has often listened to a musical contest between two or three males, who had a particularly loud voice, and were perched at a considerable distance from each other. "As soon as the first had finished his song, a second immediately began; and after he had concluded, another began, and so on." If there is so much rivalry between the males, it is probable that the females not only discover them by the sounds emitted, but that, like female birds, they are excited or allured by the male with the most attractive voice.

EXPLANATION OF PLATE X.

In all the Figures the corresponding parts are indicated by the same letters. The body of the Cicada is supposed to be placed vertically, the head being above. The three first figures are taken from the plate (Pl. XI.) illustrating M. Carlet's article in the *Annales des Sciences Naturelles.*

FIG. 1. The interior of the musical apparatus, seen from above; a vertical transverse section having been made across the body of the insect. The muscle of the drum, the folded membrane, and the *operculum*, have been removed on the left side. On the right is seen the muscle of the drum, its small triangular tendon, and its semi-annular membrane, also the tensor muscle of the folded membrane, and the lower part of the sterno-entogastric muscle in section. The deep aspect of the drum,

of the folded membrane, and of the *entogastrium*, as well as the internal opening of the metathoracic stigma, are likewise to be seen in this figure.

FIG. 2. The same apparatus seen from the side (left). The whole of the *apophysis* of the "cavern" has been removed in order to show the drum. A partial section has also been made of the *operculum* in order to show *en profile* the greater part of the details of the following figure.

„ 3. The anterior part of the musical apparatus. A section of the *operculum* on its left side has been made to show the contained organs. In order that the drum may be better seen, the bottom of the "cavern" has been raised, its entrance remaining intact.

„ 4. The lower part of the thorax and abdomen of the male of *Cicada plebeia*, seen from beneath. After fig. 2 *c'*, Planche XLV. of Cuvier's "Règne Animal: Insecta."

α. *Epimeron* of mesothorax.
β. *Epimeron* of metathorax.
γ. First abdominal "somite."

„ 5. The musical organ of the same insect laid open and seen on its ventral aspect. *Ibid.* Fig. 2, *f*.

A. Orifice of insertion of the hinder wing.
1*a*. First abdominal segment.
2*a*. Second „ „
3*a*. Third „ „
a p, Apophysis of the folded membrane.
C, "Cavern."
c, "Cheville" of Réaumur, or *trochanter* of leg of the third pair.
e, The "wing" of the *entogastrium* in fig. 1, its "body" in fig. 2. *m i*, "Mirror."
m m, Motor muscle of drum.
m p, Folded membrane.
m s, Sterno-entogastric muscle.
m t, Tensor of the folded membrane.
P, Leg of the third pair.
s, Stigma of metathorax.
s', First abdominal stigma.
s'', Second „ „
t, Drum ("timbale").
v, *Operculum* ("volet").
x, Semi-annular membrane of the muscle of the drum.

CAVES AND THEIR OCCUPANTS.

ILLUSTRATED BY THE BONE CAVES OF CRESWELL CRAGS.

By the REV. J. MAGENS MELLO, M.A., F.G.S., etc.

CAVES and their exploration have for a considerable number of years past excited a great amount of interest in the scientific world. The Physicist, the Archæologist, and the Geologist have each in their turn found in them much to occupy their attention. Physical Geology has gained from cavern researches an insight into some of those vast operations of Nature, which, carried on quietly and persistently during an incalculable number of years, have done so much in many parts of the earth, in its secret recesses, to fashion and sculpture its rocky crust. We have been taught how in numerous instances the extensive and deep valleys of our limestone districts have been actually formed by the dissolution of the solid rock, through the agency of water charged with carbonic acid gas; whilst the same rock, redeposited in an altered form, has built up those thick beds of calc-tuff so common in the same localities. The study of cavern-structure has also led to our understanding much as to the formation of mineral veins, and has brought to light many strange facts as to the circulation of subterranean water. But to many the chief interest of caverns consists in the contents so often buried in their floors, in the remains of the ancient tenants—wild beasts and men—by whom they have been alternately occupied.

Caves are common to all parts of the world, and may be met with in rocks of very varied age; not alone in the Carboniferous or Mountain Limestone, in which they are so very frequent, but also in the older limestones of Silurian age, and in those of the younger Permian and Jurassic rocks. Even sandstone rocks are in many instances, especially where exposed to marine denudation, found to be excavated into caverns of greater or less extent.

Every country has its caves. All have heard of the gigantic Mammoth Caves of Kentucky, in America, the ramifications of

which extend for miles, and in which, quite recently, most interesting relics of their early Indian inhabitants have been discovered. The famous water-caves of Styria, with their underground rivers and their magnificent stalactites, are well known to travellers; and in Sicily, Italy, Spain, France, Belgium, and England, as well as in distant Australia and New Zealand, caves of varying extent are numerous. In many of these recent explorations have discovered relics of early occupation that have proved of the utmost value to science.

A great number of caves have been found to contain so many remains of their former occupants, as to enable us to trace the history of their habitation during a long succession of ages, extending from the remote past of geological time to periods which are linked by history to the present.

Although there are some few caverns which yet contain traces of their having existed and been occupied in the Mesozoic epoch, yet in almost every case the records of cave occupation may be said to begin with that latest period of the geologist known as the Pleistocene; and we find that then, as now, the caves and dens of the earth were a refuge and hiding-place to the wild beasts. Here some of them lived and died, and here they dragged their prey, either overcome in the chase, or torn to pieces when feeble and dying. In those remote times the hyænas and the bears, the lions and the lynxes, and other carnivora, found their home in caves, just as these animals do at the present day, in the countries they now inhabit.

It is in caves that we meet with the first undoubted traces of man's existence on the earth. During some of the earliest stages of his history he appears to have used caves for the burial of his dead, and also as his habitation, often fixing upon those on the sunny side of a valley, and making them his home and his treasure-house. In the extreme north of the Asiatic continent it has been shown that a cave-dwelling people existed anterior to the Samoyedes. We read in Homer of cave-dwellers upon the shores of the Black Sea. Cave-tombs have been found in Australia, in the neighbourhood of the Gulf of Carpenteria; and we learn from the Pentateuch that the early inhabitants of Palestine buried their dead in caves; whilst recent African explorers have told us of a whole tribe of Troglodytes in the interior of that continent. Some writers have supposed that architecture itself may have had its origin in these primitive homes. From the remains of man—his weapons and his tools, his utensils and his ornaments—we may form a tolerably accurate idea of the habits and the amount of civilization, and of some of the conditions of life, of the early inhabitants of our own and of other countries. Speaking of some of the cave-dwellers in Western Europe, Sir John Lubbock writes: "Their

habits have been elucidated in the descriptions of their weapons and other implements, adapted for shooting or darting, stabbing, clubbing, cutting, chopping, scraping, boring, drilling, and other work wanted in either peace or war; in hunting or fishing, in domestic operations, and in designing the works of art which so markedly characterized this peculiar people. Their cooking stoves, hearths, and mortars; their bodkins and sewing needles; their personal ornaments, and amulets perforated for stringing; their whistling instruments, and their 'bâtons,' possibly distinctive of rank and dignity. Even their owner marks, tally scores, and probable gambling tools have been recognized and described, as well as how they made their many implements of flint."

Whilst there are some cave-remains which take us into so remote a past that we dare not assign any date to their first introduction, there are others which help to throw light upon some of the obscurer pages of history. Thus the celebrated Victoria Cave at Settle, in Yorkshire, not only carries us back to a period when the Craven savage passed through all the vicissitudes of a climate at one time mild enough for the hippopotamus to be an occupant of the Yorkshire rivers, and at another so severe in character that man may have struggled for a mere existence with the grizzly bear and the reindeer; but it also tells us how, in post-Roman times, the Brit-Welsh inhabitants of these islands were driven by the ever-advancing waves of Teuton invasion, to fly to the caves as their securest shelter and hiding-place. Here they dwelt for awhile, and by coins and various ornaments of considerable beauty and finish which they have left behind them, we are enabled, as it were, to decipher some few words in an almost illegible page of history.

Professor W. Boyd Dawkins, in his admirable work on "Cave Hunting," divides caves, according to the ages of their contents, into three classes—Historic, Prehistoric, and Pleistocene; the first being those in which remains of man or of his works have been found which can be assigned to some known historical period. In this country the occupation of Britain by the Romans is the extreme limit of age which can be admitted for historic caves, as previous to that event we have but the very dimmest tradition to guide us. Besides the human remains, those of certain animals, the approximate date of whose introduction into these islands is known, as well as the absence of others, will help us to determine the historic age of the bed in which they may be found.

The second class of caves, those called Prehistoric, are intermediate between the Historic and the Pleistocene: whilst remains of animals of late introduction are invariably absent

from them, those which specially characterize the still earlier Pleistocene deposits are ~~equally~~ absent; Man also, during the Prehistoric period, seems to have had much to do with the introduction of many of the domestic animals of Europe. "The dog, the domestic hog, the horned sheep, the goat, the Celtic short-horn, and the larger ox descended from the great Pleistocene Urus, make their appearance together with Neolithic man" (see "Cave-Hunting"); and "the wild fauna of Europe, as we have it now, dates from the beginning of the Prehistoric age, and consists merely of such animals as were able to survive the changes by which their Pleistocene congeners were banished or destroyed" (*ibid*). When we turn to the earliest class of caves, the Pleistocene, we at once recognize an enormous difference in the nature of their contents, when compared with those of the succeeding classes. First of all we are struck with the entire absence of any trace of the domestic animals in the Pleistocene deposits, whilst at the same time we encounter a large number of species, which either became extinct or else migrated to other climes before the commencement of the Prehistoric epoch, as for instance, the Cave Lion, *Elephas antiquus*, Glutton, Woolly Rhinoceros, Spotted Hyæna, *Rhinoceros hemitœchus*; Cave Bear, Bison, Mammoth, Hippopotamus, &c.

We still find the lion, the hyæna, and the hippopotamus in Africa, and the bison in Central Europe. It would appear from this migration and extinction of species that very considerable changes, both of climate and of physical geography, must have taken place between the Pleistocene and the succeeding period, involving an expenditure of time the length of which we have no certain means of estimating. The numerous researches which have been lately carried on into the contents of British caves show us that we have in this country a large number of caves representing more than one of the periods referred to; and that whilst some of the caves belong to the latest periods only, those which contain relics of the earliest period will contain also in their upper beds remains belonging to one or both of the later ones. Thus the Victoria Cave, which is in its deeper deposits of Pleistocene age, is linked to historical times by the presence of debased coins of some of the Roman Emperors, and also contains relics of Neolithic occupation. The Brit-Welsh, who were forced to seek shelter in caves from their powerful invaders, have left traces of their presence, not only in various caves in Yorkshire, but also in Staffordshire and Derbyshire, as well as in Lancashire, and as far south as Devonshire.

We must not confound the bronze ornaments found in these caves with the bronze implements, &c., which are sometimes found both in caves and tumuli of a very different date, and

which belong to Prehistoric times. The style of art displayed in these latter is of a very distinct type, which in its ruder forms of weapons shades off, as it were, into the still earlier Neolithic period.

But few remains of the Bronze age have been met with in British caves. The Neolithic period is more fully represented both here and abroad. The occupation of caves by the Neolithic men was general throughout Europe. Almost everywhere traces of these people have been met with who used the caves both as dwellings and as tombs. Not only are these men distinguished from the races which succeeded them by their physical conformation, but also by the character of their implements. These were made either of stone or bone; their stone implements being characterized by an amount of finish which is never found in those of the yet earlier men of the Pleistocene period. Their spear- and arrow-heads are elaborately constructed, and a large number of their tools and weapons are polished, so that the age in which they lived is sometimes called on this account the "polished stone age." Magnificent specimens of their implements have been found in Denmark, which for perfection of form and careful finish are unrivalled. Traces of Neolithic man have been found in the Victoria Cave and in caves in Wales; also in the celebrated cavern called Kent's Hole, in Devonshire, and in caves in Belgium, France, and elsewhere; besides others met with in lake-dwellings in Switzerland and in Ireland. Professor Dawkins has pointed out that these "Prehistoric peoples lived under physical conditions very different from those of Central and Western Europe at the present time, the surface of the country being covered with rock, forests, and morass, which afforded shelter to the elk, bison, urus, stag, *megaceros*, and wild boar, as well as to innumerable wolves. They arrived from the east with cereals and domestic animals, some of which, as the '*Bos longifrons*,' and '*Sus palustris*,' reverted to their original wild state. From the very exigencies of their position they lived partly by hunting, and they gradually pushed their way westward, carrying with them the rudiments of that civilization which we ourselves possess," and "the climate which they enjoyed was sufficiently severe to allow the reindeer to inhabit the district on which now stands the city of London. . . . The area of Great Britain was greater than now, since a plain extended seawards from the coastline nearly everywhere, supporting a dense forest of Scotch fir, oak, beech, and alder, the relics of which are to be seen in the beds of peat and the stumps of the trees near low-water mark on most of our shores."—("Cave Hunting.")

A period of unknown length, but which must have been very

great, separated the age of Neolithic man from his predecessor in the Pleistocene age,—a period in which vast changes, both of climate and physical geography, can be shown to have taken place; during this vast interval the separation of Great Britain from the continent of Europe took place, and an enormous amount of denudation, resulting in the excavation of extensive valleys, and the alteration of river-courses, made the England of to-day a very different country from what it was when the Palæolithic hunter and the Pleistocene mammalia were reckoned amongst its inhabitants.

During the Pleistocene, as during the later ages, men and wild beasts found their homes in the caves of the earth, and it is from caves that we have obtained the greatest amount of information relating to this most interesting period of the world's history.

As long ago as the beginning of the present century evidence began to be collected which tended to show that man was living in Europe in company with numerous wild animals, now either totally extinct or only found in far distant regions, such as the mammoth, the woolly rhinoceros, the hyæna, and the lion. The first evidence of this sort was obtained in Kent's Hole, in which flint implements were found in intimate association with the bones of these and other animals. The exploration of this cavern has been energetically pursued during a long series of years with most valuable results. In the same part of England similar evidence was obtained from some caves at Brixham; and later on numerous caves in this country, notably Wokey Hole in the Mendip Hills, and an extensive series of caves in Belgium and in France, have yielded to careful research such an amount of evidence, that the fact is now firmly established that man was a contemporary with a wild fauna now partially extinct, which existed in these countries under climatal conditions very different from those now prevailing.

It is somewhat startling at first, when we come to realize that in this country, now so free from wild animals, there was a time, and that time the human period, when a most formidable array of the larger carnivora roamed at will through vast forests which then spread over a great part of these isles, and yet no fact rests upon more certain evidence: from the floors of numerous caverns large quantities of the bones and teeth of these animals, representing individuals of all ages, have been extracted, many of them in the most perfect state of preservation.

Some of the latest and not least important additions to our knowledge of the Pleistocene age, and of man's coexistence with its wild fauna in England, have been made by the recent discoveries in the Creswell caves in north-east Derbyshire; and a short account of their exploration, and of the results obtained,

will show something of the nature of cave researches, and will at the same time also assist us in picturing to ourselves some of the conditions of life during what we may look upon as the dawn of the human period in Great Britain.*

The caves of Creswell are beautifully situated in a small craggy ravine in the Magnesian Limestone on the border of the counties of Derby and Nottingham (fig. 1.). They are of no great size, being little more than enlarged fissures. Three of these have been carefully examined since their discovery as bone caves by

FIG. 1.

VIEW OF CRESWELL CRAG, LOOKING EAST.†

the writer in 1875, and they are known as the Pin Hole, the Robin Hood Cave, and the Church Hole. The last two are the largest and also the most important, especially on account of the abundant traces of man's handiwork in conjunction with very numerous bones of the extinct mammalia, which are distributed throughout the soil forming their floors.

The Pin Hole cave is a long and narrow fissure, containing under a thin crust of recent surface soil a bed of red sand about three feet thick. This was found to be full of bones, many of them broken and gnawed, belonging to about eleven genera of mammals of the Pleistocene period, but without any distinct traces of man's presence, although there are, as we shall see, so

* See Papers by Professors Busk, W. Boyd Dawkins, and the writer, in the "Quart. Journ. Geol. Soc." for November 1875, August 1876, and August 1877.

† This and the other figures illustrating this paper, have been kindly lent to us by the President and Council of the Geological Society.

many in the adjoining caves. This, however, is what might be expected; the larger and more commodious caves would certainly have been preferred to the narrow fissure, by the early inhabitants, for a house or sheltering-place. When we come to notice the animal remains we shall find but little difference in the contents of these caves, the presence or absence of some species in one or other of them being evidently accidental. The two larger caves, the Robin Hood and the Church Hole, were found to contain a considerable thickness of deposited material; and a reference to the sections (figs. 2, 3) will serve to show how the floors of bone caves are built up. Sealed up under a crust of stalagmite and breccia a series of well-marked beds were found. This stalagmitic breccia consisted of masses of limestone fallen from the roof, and cemented together during the lapse of an indefinite period of time by the constant dripping of water charged with carbonate of lime. Below the breccia was a deposit of sandy earth, commonly known as cave earth, of variable thickness, and passing at its base into a curiously mottled bed of reddish earth, filled with light-coloured fragments of friable limestone; this in its turn rested on red sand, similar to that mentioned as occurring in the Pin Hole, and under this was the decomposed floor of the cavern, the whole amount of deposited materials being about eight or nine feet thick. It may be observed that the contents of the Robin Hood and Church Hole caves were very similar to each other, and were probably brought in at the same period under identical conditions.

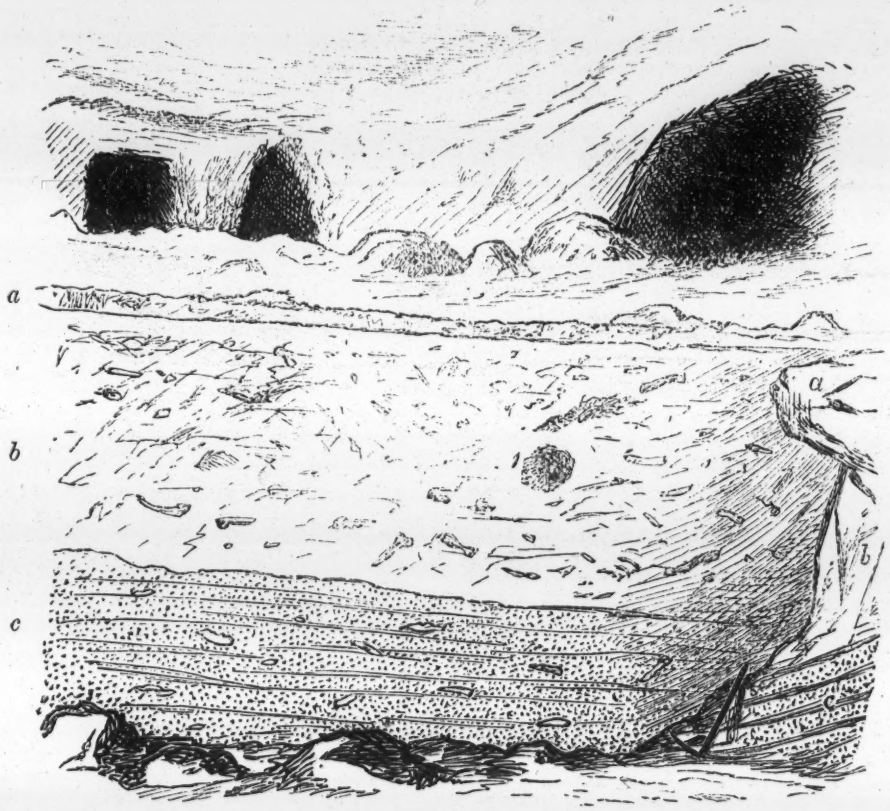
It is in these various beds, forming the floors of the caves, that the bones and implements have been obtained which enable us to reconstruct the life-history of the past.

Commencing our researches in the surface-deposits in the Church Hole and the Robin Hood caves, we are at once carried back into that unsettled period of British history when the Roman legions were withdrawn, and the comparatively civilized British population had to resist as best they might the hordes of Teuton invaders, for in the surface soil of these caves a few traces of Romano-British art have been met with: these consisted of two or three harp-shaped and circular brooches, one of the former being enamelled with blue. In conjunction with these, numerous fragments of pottery, one or two being of the well-known red Samian ware, were found; and the surface-soil also contained a large number of bones of animals common at that time, such as the sheep, goat, Celtic shorthorn, stag, wild cat, badger, fox, and horse.

Previous to this post-Roman occupation of the caverns, there seems to occur a long blank period, as far as man, at any rate, is concerned; for no distinct traces of Neolithic times have been

met with, no relic of the age immediately preceding that of written history; in the hard stalagmitic breccia which separates the surface-soil from all below it we at once meet with the implements of Palæolithic man, and the bones of the Pleistocene mammalia. Throughout the breccia, and in the various beds of cave-earth and red sand below it (see figs. 2 and 3), a vast quan-

FIG. 2.



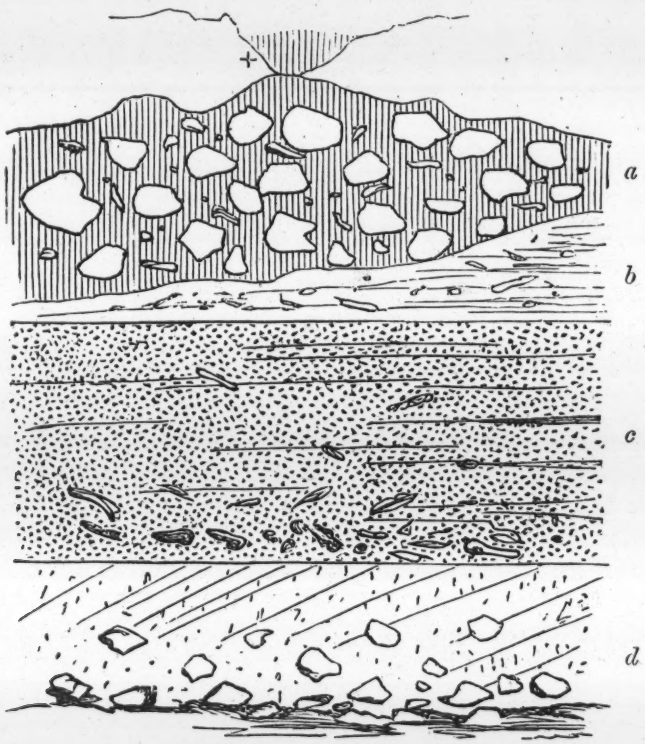
SECTION IN THE ROBIN HOOD CAVE.

a. Surface soil and thin breccia, 2–3 in.
b. Cave-earth, with flint and quartzite implements, teeth, bones, angular limestone fragments, and charcoal, 3 ft.
c. Red Sand with laminated clay, few bones 3 ft.
1. Fox Hole?

tity of bones and teeth of animals were found, affording to the imagination a vivid picture of the abundant wild fauna of the district. About twenty different species have left their remains here, some of them, such as the horse, the rhinoceros, and the hyæna, in remarkable numbers. Is it asked how all these bones got entombed here, we have to point in the majority of cases to the hyænas. These savage animals would, during the absence of man, be the lords of the caves, to which they would drag their numerous victims, and where they would devour them. The majority of the bones of the other animals, and even of the

hyænas themselves, are in fact covered with tooth scorings, which have been shown to be identical in character with those made by hyænas at the present day; and even such powerful animals as the rhinoceros and the mammoth might not unfrequently fall a prey to the hyænas, who would attack them when enfeebled by disease, accident, or age, or even when young they would sometimes be overcome by sheer force of numbers; or the hyænas, often hunting in packs, would occasionally drive them over the precipices, and fall upon them as they lay crippled at

FIG. 3.



SECTION IN THE ROBIN HOOD CAVE.

× Stalagmite uniting breccia with roof.
a. Stalagmitic breccia, with bones and implements, 18 in. to 3 ft.
b. Cave earth, with bones and implements of variable thickness.
c. Middle red sand with laminated clay at base, containing bones, 3 ft.
d. Light-coloured sand, with limestone fragments.

the bottom. In the Creswell caves, as in so many other of the British ones, the remains of hyænas, representing individuals of all ages, have been found, from the young cub just cutting its teeth to the veteran who has little of them left save the well-ground stumps. The species of hyæna thus found is the *Hyæna crocuta*, almost, if not quite, identical with the Spotted Hyæna now met with only in South Africa. The more common Striped Hyæna has also been met with in caves, but not in England.

Amongst the larger beasts of prey found at Creswell are the lion and the panther. The cave lion only differed in size from that of the present day. Like most of the wild animals of the Pleistocene age, it was larger and more powerful. Throughout Europe, from Italy in the south to the wilds of Yorkshire in the north, the lion was commonly met with, although it is now found only in Africa and in parts of Asia; but there is some evidence that it was still existing in south-eastern Europe as lately as the first century of the Christian era. One of the most remarkable animals that appears to have once inhabited middle as well as southern England was a large feline species that must have been a terror to its weaker contemporaries. This was the *Machairodus latidens*, a beast armed with teeth that have been not inaptly compared to sabres, the canines being thin and recurved blades, with serrated edges, of the most formidable appearance. The remains of this animal, which have been met with in some abundance in France, until it was discovered in the Robin Hood's cave, had only twice before been found in England—in Kent's Hole, in Devonshire, where a few teeth occurred in conjunction with other Pleistocene bones. At Creswell only one canine has been found, possibly brought there by a human hand, but not improbably also denoting the occurrence of the Machairodus as a contemporary of the lions, bears, and hyænas of the surrounding country.

Enough bones and teeth of bears have been discovered in the Creswell caves to denote the existence of at least two large species, the great grizzly (*Ursus ferox*) and the brown bear (*U. arctos*). The first of these is identical with the present species familiar to the North American fur-hunters; and the smaller brown bear is not uncommon in many parts of Europe. It was still living in Scotland as recently as A.D. 1057, when the last specimen is said to have been killed. Another bear, now extinct, common to caves—the huge cave bear (*U. spelæus*)—has not been certainly met with at Creswell, but is common in many other caverns, both in England and abroad.

Remains of wolves and foxes occur in all the Creswell caves; some of the former denoted very large animals, and have been thought by Professor Busk to have been possibly allied to the arctic, or North American, rather than to the existing European species. If this be the case it will then have been a fit companion for such animals as the arctic fox, the glutton, and the reindeer, all of which have been found in British caverns, the Arctic fox having been recognized for the first time in this country in the remains from the Pin Hole cave at Creswell; it appears, however, to have abounded formerly in Belgium, and even as far south as Switzerland, and to have been well known to the Palæolithic hunters, who have skilfully engraved its

likeness on some of their bone implements. It is also from the Pin Hole that the only trace of the glutton, as occurring at Creswell, has been derived. This animal is the Wolverine of the North Americans. It also lives in Siberia, and its bones have been found in several British caves, as well as in those of Belgium. Its presence is, as has been observed, significant of the prevalence of a severe climate. In Kamtschatka, where it is sometimes found, its skin is so highly prized by the natives that they say the heavenly beings are clothed in it.

The principal ruminants whose bones and teeth have been found at Creswell are the great ox, or urus; a lesser species, known as the Celtic shorthorn (*Bos longifrons*); the bison, and various deer, the most prominent of which are the reindeer and the megaceros, sometimes called the Irish elk. The huge urus (*B. primigenius*), the bones of which were found in the Pin Hole, was not only common in Pleistocene times, but was also known to the Romans, and, except in size, there is no real difference between it and the existing ox: the wild cattle of Chillingham, in fact, are supposed by some writers to be its direct descendants. The size of this animal in the Pleistocene period was, however, immense, being as much as six feet high, and from eleven to twelve feet long. Professor Owen has remarked that "the extensive range it had, when in former times it wandered at will in vast herds over the whole of England, and the abundant food it would find, tended to its development, whilst after the submergence of the old Pleistocene lowlands it would have had a harder battle to fight, and would thus have degenerated. This, and the hostility of man, may help to account for the greater size of nearly all the Pleistocene mammalia, as compared with their descendants." It has been observed that the Urus seems to have held its ground after the elephants, rhinoceroses, hyænas, and other animals had retreated southwards, although in Roman times it was probably scarce; still, we read of its existence in a wild state, together with the bison, as late as the close of the eleventh century, near Aachen, and in Poland even up to the sixteenth century.

In the red sand bed of the Creswell caves remains of the bison were tolerably numerous. This animal, which still lives in North America as well as in the forests of Lithuania, was a contemporary of the Urus, and with it disappeared from history; it does not seem to have been known in historical times in Northern Europe.

Reindeer remains, teeth, bones, and broken antlers—the bones and antlers, with few exceptions, having been gnawed by the hyænas—were very abundant at Creswell, both old and young animals being well represented. The reindeer seems to have ranged throughout the greater part of Europe, and with other

Arctic animals was hunted by the ancient cave-dwellers as far south as the Pyrenees. Contemporary with these animals was the great Irish elk (*Cervus megaceros*). This huge deer, the remains of which are not unfrequent in caves, had also a wide range, from Ireland and England, through France, Germany, and Central Italy. The bones of several individuals, one of them being of unusually large size, were found at Creswell.

One of the most abundant animals, the bones of which were found in the Creswell caves, were those of the small Pleistocene horse, and it would doubtless have formed a staple article of food, not only to the hyænas and other carnivora whose teeth-marks are so common on its bones, but also to the early cave men, who did not share the prejudice or superstition against the use of horseflesh which prevailed in later times. No trace of the musk ox, which is not uncommon elsewhere, has been found in these caves, although it may have been an inhabitant of the neighbourhood. The animals which it is perhaps the most difficult for us to realize as having been contemporaries with man in England, are the woolly rhinoceros (*R. tichorhinus*) and the mammoth (*Elephas primigenius*). Yet few facts are more certain than that primeval man must have constantly encountered these creatures as he went out on his hunting expeditions. Three species of rhinoceros inhabited England during the Pleistocene period. The one most frequently met with is the two-horned woolly rhinoceros, which, besides being hairy, like the mammoth, had also a smooth skin, contrasting in this with the existing species with its thickly-folded covering. It was apparently fitted to undergo a far severer climate than any of its living relatives. Its remains are found very widely spread; some are imbedded in the frozen mud of the Lena in Siberia, and from caves and gravel beds over a large part of Europe its bones have been obtained; these as well as teeth found in the Creswell caves show that this animal was plentiful in the neighbouring country, and the gnawed condition of its bones shows that it fell a frequent prey to the hyænas, whilst a large number of milk teeth found show that many young individuals were present. This was also the case with the next animal to be noticed, the mammoth. All three of the caves explored at Creswell have yielded teeth and bones of the mammoth, some of the former being from adults, but very many were milk teeth: this is what we should naturally expect, as it is hardly likely that hyænas would often obtain the mastery of the full-grown animal unless it happened to be maimed or otherwise enfeebled. The mammoth, with its shaggy hair and huge recurved tusks, was doubtless, like the woolly rhinoceros, capable of enduring great extremes of cold; its remains have also been found frozen at the Lena in so fresh a condition

that its flesh was eaten by the dogs and wolves. It is said that the Læchow islands off north-east Siberia were one mass of the bones of the mammoth, whole cargoes of ivory having been exported thence for the greater part of a century. Indeed, the number of mammoths inhabiting Northern Europe must have been prodigious. In the midst of the Channel between Dover and Calais a mass of their bones has been dredged up; and thousands of their teeth have been obtained in a similar manner off the coast of Norfolk. The range of the mammoth was very wide, as not only in Siberia and in these islands have its remains been discovered, but also in Russian America, and in Europe as far south as Spain in the west and Rome in the east. Two other elephants besides the mammoth were living with it in this country, but their remains are not so common, and they have not been found at Creswell. One of them, the *E. antiquus*, had a range nearly as great as that of the mammoth.

The other animals which existed during the Pleistocene period, and whose remains have been obtained in the Creswell caves, do not call for any very special notice; amongst them were hares and voles, the bones of both which are very plentiful. The hare was doubtless a common article of food with the early inhabitants.

We must now turn to the evidences of man's existence as a contemporary of all these animals, as proved by the explorations at the Creswell caves. That man was present during the early Romano-British period we have already seen; but an examination of the ossiferous breccia of the Robin Hood and Church Hole caves, as well as of the various beds sealed up under it, has proved that man was also, at any rate, an occasional occupant of these caves during the long antecedent Pleistocene times, for although we do not find human bones, various implements and weapons of undoubted human workmanship occur in intimate connection with the remains of the extinct mammalia.

It is sometimes asked how it is that human bones seldom, if ever, are found in these earliest deposits? It is surely easily accounted for by the consideration that the proportion borne by the men of that period to the wild beasts would be but as one to many thousands, and it would be an extraordinary thing were many human bones present. But no one can now seriously question the human origin of the many and various implements of the Pleistocene age; it is true that many of them are rude in the extreme—so rude that individual specimens taken by themselves might make us hesitate before deciding upon their origin; but mingled with these are others far more elaborate in workmanship, and besides the stone implements which give to

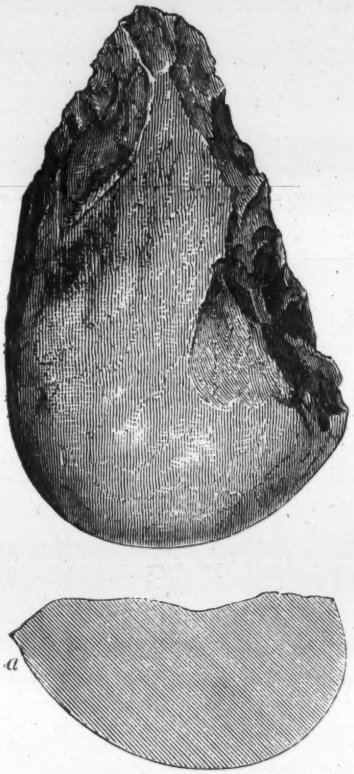
this age of man the name Palæolithic, there have been found numerous specimens of arrow-heads, awls, needles, harpoons, &c., made of bone and reindeer antlers. Some of the bone implements are carved with not unskilful ornamentations, figures of animals not being unfrequent, and amongst these are well-executed engravings of horses, the reindeer, the arctic fox, and even of the mammoth, most clearly proving that the men who executed them must have been familiar with the forms of these animals, and we can therefore only come to the conclusion that they were contemporaries. Such bone implements and specimens of primitive art, as well as implements of stone, have been met with in the caves of France, Belgium, and Switzerland. A few bone tools, and notably some harpoon heads, have been found in this country in Kent's Hole.

Looking now at the Creswell caves, the sections of their floors show us a distinct series of beds of sand, earth, and breccia, accumulated upon the original floor of the caverns. In each of these deposits we have distinct traces of human occupation, and what gives additional interest to them is, that they bring before us very clear evidence of an advancing civilization: as we rise from the lower to the upper beds, we have a most decided progress shown in the character of the implements derived from the several deposits.

In the bottommost bed of red sand (see sections, figs. 2, 3) mingled indiscriminately with the bones and teeth of the various animals already described, occurred tools of the very rudest description, manufactured out of the quartzite pebbles which abound in the district. Some of these have been used as hammers, the proof of which is seen in their bruised and chipped ends; other pebbles had been split into rough flakes (figs. 4–6), which may have served various purposes as knives, choppers, and scrapers for the preparation of skins. Implements as rude as these are said to be still in use amongst the Shoshone and Wyoming Indians, and equally rude ones have been found at the Cape of Good Hope. We may picture to ourselves a race of savages who, in pursuit of the horse, the reindeer, and even of the mammoth and other animals we have spoken of, visited the neighbourhood of Creswell and made use of its caves as convenient dwellings or sheltering places, driving off for a time the hyænas, who would return again to their dens during the absence of these primitive hunters. How long a time elapsed during the accumulation of each bed in these caves we have no possible means of judging, but as we pass upwards from the red sand into the succeeding cave earth, we not only find similar quartzite implements, but also a few others made from flint. Still there was in these latter none of that perfection of workmanship arrived at by the later users of that material;

apparently a lengthy apprenticeship was required before the skill to adapt even this more tractable stone could be acquired. It was in the upper part of the cave earth and in the breccia that a higher class of work made its appearance in these beds, accompanying, be it observed, the remains of the Pleistocene

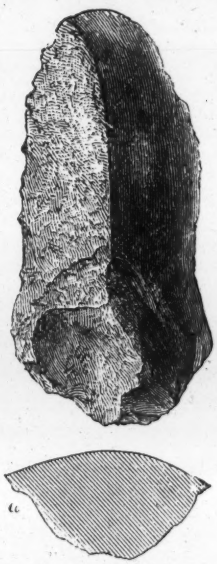
Fig. 4.



QUARTZITE HACHE, HALF NATURAL SIZE.

a. Section. Cave earth.

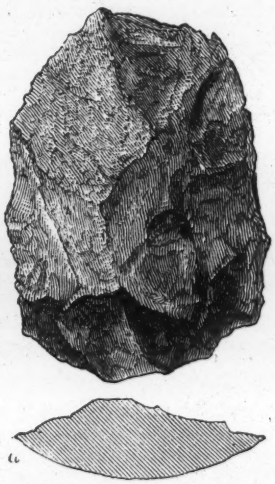
Fig. 5.



QUARTZITE FLAKE, × $\frac{1}{2}$.

a. Section. Cave earth.

Fig. 6.



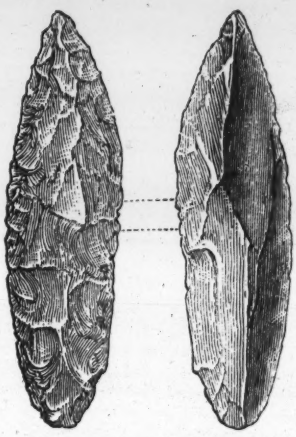
OVAL QUARTZITE IMPLEMENT, × $\frac{1}{2}$.

a. Section. Cave earth.

mammalia, and numerous implements, some of quartzite, others of flint, and two or three of clay ironstone (fig. 7) were found, and with these were also fragments of charcoal, showing that man was in the habit of using fire. Some of the quartzite and also the ironstone implements were, it has been observed, "of the same form as those which have been discovered in the river gravels of Brandon, Bedford, and Hoxne, and which occur in those of France, from St. Acheul, near Amiens, as far as the district round Toulouse, and always in association with the mammoth, reindeer, and woolly rhinoceros. Others with curved hatchet edges, notched by use, were choppers, like those met with in the bone caves of Dordogne under very similar circumstances as at Creswell, by MM. Lartet and Christy;

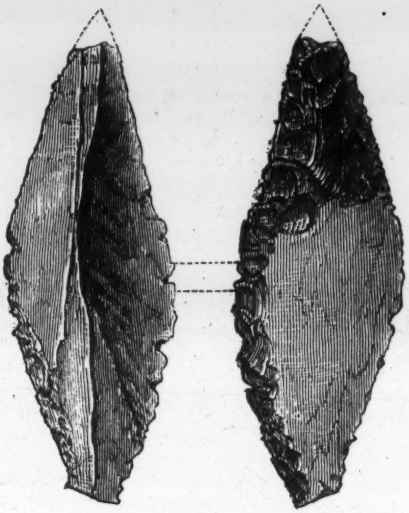
and the natural surface of the pebbles from which they were made was left untouched, so that they might be conveniently

Fig. 7.



OVAL INSTRUMENT OF CLAY-IRONSTONE, × ½.

Fig. 8.



LANCE-HEAD OF FLINT, × ½
Breccia.

grasped by the fingers. There were also many triangular flakes intended for cutting purposes, and scrapers intended for the

Fig. 9.

FLINT SCRAPER, × ½
a. Section. Cave earth.

Fig. 10.

FLINT-BORER. (FULL SIZE).
Breccia.

preparation of skins. The implements of flint also were very numerous (figs. 8–10): flakes, scrapers, beautifully-chipped lance-heads, of the same form as those found in the bone caves of Wookey Hole, near Wells, Kent's Hole, near Torquay, and in

France, at Solutré; borers and awls, in some cases worn by use, as well as small oval forms bearing a close resemblance to the carefully chipped stonecutters used by the Eskimos for

FIG. 11.

POINT MADE OF ANTLER (full size).
Cave earth. Robin Hood Cave.

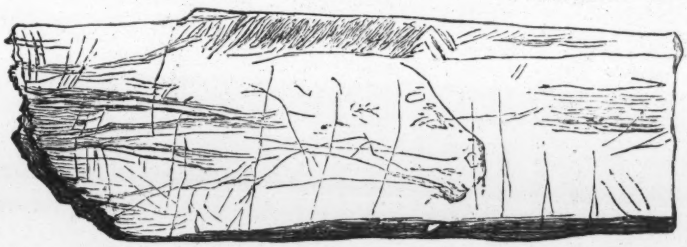
FIG. 12.

ROD OF REINDEER ANTLER.
Church Hole Cave.

planing wood. Some of the flakes had obviously been let into a handle of wood, or some other perishable material, which protected one edge while the other was completely worn away. Articles of bone and antler were also met with—bone awls, a well-finished bone needle, and cylindrical rods of antler, which may have been portions of the points of spears" (figs. 11, 12). One of the most interesting discoveries made in this part of the floor of the Robin Hood cave was a fragment of rib having engraved upon it the head and forepart of a horse (fig. 13). This is the only instance in which a trace of what we may term Palæolithic high art has been met with in this country, and it is of extreme interest, as correlating these caves with those of the Continent in which similar works have been found; engravings of the reindeer, of the arctic fox, and even of the mammoth, as has been observed, having been obtained from the caves of France, Switzerland, and Belgium. We thus have brought before us in the Creswell caves a most important chapter in the history of early man, a sequence of implement-bearing beds showing a progress in civilization such as has "not been observed in any other series of caverns in any part of the world." We learn that even the Palæolithic age of man has its periods:

the earliest, that in which man was a savage in the very lowest state of culture, with such tools only as he could roughly fashion out of the nearest pebbles, a single flake or two struck from their sides being sufficient to adapt them for their respective uses, whether as axes, or hammers, or scrapers. Then came the discovery of flint as a more tractable material, and also giving sharper cutting edges; and flint tools were gradually improved, and bone and other materials were also made use of. The men who used the more perfectly shaped implements, especially those made of bone, must have been in a higher state of civilization than those who had but a broken pebble; and the discoveries at Creswell, where the more finished type of implements is found above the ruder, show that the more civilized man succeeded the earlier savage race, or else that this latter, in the course of ages, improved in the arts of tool-making, and learnt not only to shape the flint

Fig. 13.



FRAGMENT OF RIB WITH ENGRAVING OF HORSE (full size).
Cave earth. Robin Hood Cave.

more elaborately, but also to make use of bone for domestic and other purposes. What these Palæolithic men were like we have no certain means of knowing, but it has been shown by a careful comparison of their implements and habits of life, so far as these latter can be ascertained, that they may not improbably have been of the same race as the existing Eskimos, a hardy race of hunters and fishermen, who have in the long course of ages been driven gradually, in company with the reindeer and other arctic animals, to more northern climes. It is strange for us to realize that these men once speared their fish in the ice-bound rivers of England and France, roaming with the changing seasons as far to the south as Switzerland, and to the north as Derbyshire and Yorkshire in England, in pursuit of such animals as the horse, reindeer, urus, bison, and even the rhinoceros and mammoth. It is strange indeed to realize all the wondrous changes of climate, physical geography, and of human history, that have taken place since that remote past, when man, the hunter and fisherman, made his home in the caves, and wandered through the far-extending forests and swamps of these countries.

We are carried back in thought to days when the Scottish, English, and Welsh highlands were bound in an icy raiment; when large glaciers descended from the mountain flanks into the valleys, where the reindeer, the musk ox, the glutton, and the arctic fox found a congenial home, and where also the animals of warmer climes were constant visitors: days when England was united to Europe, and even the hippopotamus could find its way, unhindered by ocean barriers, into the rivers of Yorkshire. We may perhaps picture to ourselves conditions somewhat like those yet prevailing on the western coast of South America, where the glacier descends into plains of almost tropical heat; and we can understand how, under such circumstances, the severity of an arctic winter would force the animals of the northern regions to migrate even as far south as the Pyrenees, whilst the returning heat would tempt snch animals as the lion, the leopard, the hyæna, and the hippopotamus as far to the north as central England. We thus find commingled in one common grave, bones in a perfectly similar state of preservation, evidently lying where they were first deposited—a clear proof of contemporaneity of the representatives of faunas which are now so widely separated. Strangely different must have been the England of those days. Through the centre of that region now occupied by the German Ocean flowed a great river, rising far south in the Alps, and receiving among its tributaries the Thames and the Humber; from its banks probably stretched extensive forests and grassy plains, whilst on the other side of England similar plains and forest tracts occupied what is now sea. Through this country the various animals we have spoken of all wandered at will—deer and oxen, and horses, rhinoceroses, and elephants, and the savage carnivora; whilst amongst them Palæolithic man hunted and fished, and fought for his life. Gradually the conditions of the country changed, may be after a period of intense cold, accompanied by physical change, during which the Pleistocene men and animals gradually passed away, or migrated; a more genial climate prevailed, and with it came also a more civilized race of men, the men of the Neolithic period, bringing with them domesticated animals and the appliances of a higher culture. Age after age has thus passed by, and tribe after tribe has pushed on from far distant homes to people new lands, and the newcomers have even displaced the earlier ones. Civilization has replaced little by little the rude contrivances of old by the varied implements which subserve man's many wants in these more artificial days. The rough tools and weapons of stone, bone, or horn gave place to others of bronze, and then of iron. The cave was forsaken for the hut, in its turn to be left for the house of brick or stone; the wild hunter, fisherman, and shepherd has been followed by the civilized

man of to-day, before whom the wild beasts of the caves and the forests have disappeared, some for ever, others only to be found again far from the daily haunts of man. Thus may we trace out the stages of human progress. "Man alone," says Professor Nilsson, "can make progress; he alone can throw aside his first rude weapons, alter them according to his improved cultivation and more refined activity. Man, that he might become the most powerful, was made at first the weakest. Through that alone he was induced to develop his higher talents, for it was not by bodily strength but by the power of the mind that he was to be the king and lord of the earth."

METEORITES AND THE ORIGIN OF LIFE.

By WALTER FLIGHT, D.Sc., F.G.S.,

Of the Department of Mineralogy, British Museum; Examiner in Chemistry and Physics, Royal Military Academy.

THE question which has so often been raised, How did life originate on our earth? has again been brought before the consideration of the scientific world by Professor Allen Thomson, in the Presidential address delivered at the Plymouth meeting of the British Association during the present autumn. One explanation to which he refers is that which formed a prominent feature in the address of a former occupant of the Presidential chair, Sir William Thomson, who six years ago suggested as a possible solution of this great question that the germs of life might have been borne to our globe by the meteorites which are scattered through space, and which from time to time fall upon the surface of our planet. If, he maintained, we trace back the physical history of our earth, we are brought to a red-hot melted globe on which no life could exist. The earth was first fit for life, and there was no living thing upon it. Can any probable solution, consistent with the ordinary course of nature, be found to explain the problem of its first appearance? When a lava stream flows down the side of Vesuvius or Etna it quickly cools and becomes solid, and after a few weeks or years it teems with vegetable and animal life, which life originated by the transport of seed and ova and by the migration of individual living creatures. When a volcanic island emerges from the sea, and after a few years is clothed with vegetation, we do not hesitate to assume that seed has been wafted to it through the air, or floated to it on rafts. Is it not possible—and if possible, is it not probable—that the beginning of vegetable life on the earth may be similarly explained? Every year thousands, probably millions, of fragments of solid matter fall upon the earth. Whence came they? What is the previous history of any one of them? Was it created in the beginning of time an amorphous mass? The idea is so un-

acceptable that, tacitly or explicitly, all men discard it. It is often assumed that all, and it is certain that some, meteorites are fragments severed from larger masses and launched free into space. It is as sure that collisions must occur between great masses moving through space as it is that ships, steered without intelligence directed to prevent collisions, could not cross and re-cross the Atlantic for thousands of years with immunity from such catastrophes. When two great masses come into collision in space it is certain that a large part of each of them is melted; but it appears equally certain that in many cases a large quantity of *débris* must be shot forth in all directions, much of which may have been exposed to no greater violence than individual pieces of rock experience in a landslip or in blasting by gunpowder. Should the time when this earth comes into collision with another body, comparable in dimensions to itself, be when it is still clothed, as at present, with vegetation, many great and small fragments carrying seed and living plants and animals would undoubtedly be scattered through space. Hence and because we all confidently believe that there are at present, and have been from time immemorial, many worlds of life besides our own, we must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space. If at the present instant no life existed upon this earth, one such stone falling upon it might lead to its becoming covered with vegetation. "I am fully conscious," he concludes, "of the many scientific objections which may be urged against this hypothesis, but I believe them to be all answerable. . . . The hypothesis that life originated on this earth through moss-grown fragments from the ruins of another world may seem wild and visionary; all I maintain is that it is not unscientific." *

Sir William Thomson's views, thus plainly set forth, did not fail to attract adverse criticism. Before we proceed to consider the comments which his hypothesis called forth, we may call the reader's attention for a short time to speculations in the same direction which have appeared in the writings of scientific men in France and Germany.

First, we must refer to a remarkable passage in the great work of Count A. de Bylandt Palstercamp, on the Theory of Volcanos.† He wrote in 1835, at a time when Laplace's theory that meteorites were hurled at us from lunar volcanoes was still generally received, and this will account to some

* "Address of Sir William Thomson, Knt., LL.D., F.R.S., President." London: Taylor and Francis. 1871. P. 27.

† "Théorie des Volcans. Par le Comte A. de Bylandt Palstercamp." Paris: Levrault. 1838. Tome i. p. 95.

extent for the source of the cosmical masses of which he treats. What is mainly worthy of notice is their character, of carriers of the faculty of organization, which he attributes to them. In the chapter intituled "Principe d'après lequel le premier développement de notre globe peut s'être effectué?" he writes: "It may be a matter of curiosity, but it is in nowise necessary, that we should know on what principle or from what organized body the great mass of our globe has been derived; it is sufficient for us that we exist in a manner where everything is perfectly organized, at least in so far as the aim of our existence is concerned. Many scientific men have exercised their imagination on this problem without being able to come to any definite decision. Some maintain that the nucleus of our globe was a fragment of a body which in its cosmical path had dashed itself into fragments against the sun, which the very close proximity of some comet to that star gives grounds for believing. Others suppose us to be a vast aerolite thrown off from the sun himself* with a force proportional to its mass, to a zone where the motion is determined in accordance with the laws of reciprocal attraction, and that this fragment carried in itself the germ of all that organization which we see around us, and of which we form a part. (*Que cet éclat portait en lui le germe de toute cette organisation que nous observons ici et dont nous faisons partie.*) They suppose the satellites to be small parts or fragments detached from the chief mass by the violence of the rotation at the time it is hurled forth, or by the excessively high original temperature, increased by the fall, which produced a very violent dilatation of the matter, and severed some portions from it. These aerolites, it is said, by way of comparison, contain within them the principle common to the body whence they have been derived, just as a grain of seed carried by the wind is able to produce at a remote distance a tree like its prototype, with such modifications only as are due to soil or climate."

In the spring of 1871 Professor Helmholtz delivered at Heidelberg and at Cologne a discourse on the origin of the solar system, which he printed in the third collection of his interesting "Populäre wissenschaftliche Vorträge," published last year.† He directed attention on that occasion to the facts that meteorites sometimes contain compounds of carbon and hydrogen, and that the light emitted by the head of a comet gives a spectrum which bears the closest resemblance to that

* He alludes here in a note to the theory held by Laplace and others.

† "Populäre wissenschaftliche Vorträge. Von H. Helmholtz." Braunschweig: Vieweg und Sohn. 1876. Drittes Heft. p. 135.

of the electric light when the arc is surrounded by a gaseous hydrocarbon. Carbon is the characteristic element of the organic compounds of which all things living are built up. "Who can say," he asks, "whether these bodies which wander about through space may not also strew germs of life where a new heavenly body has become fitted to offer a habitat to organized creatures?" The hypothesis, in the form set forth in 1871 by Professor Helmholtz and Sir William Thomson, was vigorously handled by Zöllner, of Leipzig, whose work, "Ueber die Natur der Cometen," appeared in the following year. In the *Vorrede* of his book he passes his countryman by unmentioned, but declares Sir William Thomson's proposition to be unscientific, and that in a twofold sense. In the first place, he maintains it is unscientific in a formal or logical sense, in that it changes the original *simple* question, Why has our earth become covered with organisms? into a second, Why had that heavenly body the fragment of which fell upon our planet become covered with vegetation, and not our earth itself? "If, however," he adds, "bearing in mind an earlier dictum,* we regard inorganic and organic matter as two substances from all eternity diverse, just as in accordance with our present views we consider two chemical elements to be diverse, such an hypothesis as that now advanced must be at variance with the destructibility of organisms by heat which experience has taught us."

"Again," contends Zöllner, "the hypothesis in its *material* bearing is unscientific. When a meteorite plunges with planetary velocity into our atmosphere, the loss of *vis viva* arising from friction is converted into heat, which raises the temperature of the stone to a point where incandescence and combustion take place. This, at all events, is the theory at present generally held to explain the phenomena of star-showers and fire-balls. A meteorite, then, laden with organisms, even if it could withstand the sundering of the parent mass unscathed, and should take no part in the general rise of temperature resulting from this disruption, must of necessity traverse the earth's atmosphere before it could deliver at the earth's surface organisms to stock our planet with living forms." †

Helmholtz did not long delay in replying to Zöllner's criticism on this question. An opportunity occurred during the publication, in the following year, 1873, of the second part of the German translation of Thomson and Tait's "Handbook of Theoretical Physics." The preface contains Helmholtz's

* "Dead matter cannot become living matter unless it be subject to the influence of matter already living."

† "Ueber die Natur der Cometen. Von J. C. F. Zöllner." Leipzig: Engelmann. 1872. p. 24.

answer.* He points to the fact, confirmed by numerous observers, that the larger meteoric stones, during their transit through our atmosphere, become heated only on the outer surface, the interior remaining cold—often very cold. Germs which may happen to lie in the crevices of such stones would be protected from scorching while travelling through the air. Those, moreover, which lie on or near the surface of the aerolite would, as soon as it entered the upper and and most attenuated strata of our atmosphere, be blown off by the swift and violent current of air long ere the stone can rend those denser layers of our gaseous envelope where compression is sufficiently great to cause a perceptible rise of temperature. As regards that other point of debate, referred to by Thomson only, the collision of two cosmical masses, Helmholtz shows that the first result of contact would be violent mechanical movement, and that it is only when they begin to be worn down and destroyed by friction that heat would be developed. It is not known whether this may not continue for hours or days, or even weeks. Such portions as at the first moment of contact are hurled away with planetary velocity may consequently be driven from the scene of action before any rise of temperature may have taken place. "It is not impossible," he adds, "that a meteorite or a swarm of meteorites, in traversing the upper layers of the almosphere of a heavenly body, may either scatter from them or carry with them a quantity of air containing unscorched germs. These are possibilities which are not yet to be taken as probabilities; they are questions which, from the fact of their existence and range, are to be kept in sight, so that, should a case arise, they may receive an answer either by actual observations or by some conclusive deduction." It should be mentioned here that these views of Helmholtz's are also to be met with in a supplement to his lecture on the origin of the solar system.

In tracing the gradual development of this important controversy we now arrive at the present year, and proceed to discuss the allusion made to it by Professor Allen Thomson in his address at Plymouth. The difficulty regarding the origin of life is, he considers, not abolished, but only removed to a more remote period, by the supposition of the transport of germs from another planet, or their introduction by means of meteorites or meteoric dust; for, besides the objection arising from the circumstance that these bodies must have been subjected to a very high temperature, we should still have everything to learn as to the way in which the germs arose in the

* "Handbuch der theoretischen Physik. Von W. Thomson und P. G. Tait." Uebersetzung von H. Helmholtz und G. Wertheim. Braunschweig: Vieweg und Sohn. 1874. Erster Band. Zweiter Theil. 11.

far distant regions of space from which they have been conveyed. At one of the Sectional meetings, a few days later, Sir William Thomson made these observations the text of a further communication on the now well-worn subject. He desired to limit the discussion to the bare dry question, Was life possible on a meteorite? The hypothesis which was to explain the bringing of life to our earth did not pretend to explain the origin of life, and he would not attempt to offer an explanation of the origin of life. The three questions which presented themselves were these: Was life possible on a meteorite moving in space? Was life possible on a meteorite while falling to the earth's surface? and, Could any germs live after the meteorite had become imbedded in the earth? A meteorite may be exposed to great heat before it reaches the earth; whether or not life on that meteorite would be destroyed by that heat was dependent on the duration of exposure. If a meteorite traversed space with the same side always exposed to the sun that side would be strongly heated, the other would be cold; if it spun round at a uniform rate all its surface would be of one uniform temperature; and if it rotated once per hour it would have a high temperature on one side and be as cold as ice on the other. The whole or part of the surface of a meteorite might afford a climate suitable to some living forms, destructive to others. When the moss-covered stone enters the atmosphere the germs upon its surface would be torn off long before the stone became heated, and in a few years they may settle down on the earth, take root, and grow. But were the germs of the exterior destroyed by heat, there might still be vegetable life in the interior. The time occupied by a stone in its passage through the air would not be more than twenty or thirty seconds at the outside, so that the crust might be fused, while the interior might have a moderate temperature, and anything alive in it would fall to the earth alive. Sir William Thomson concluded by remarking that after the collision of cosmical masses fragments must be shot off, some of which must certainly carry away living things not destroyed by the shock of the collision, and he did not hesitate to maintain, as a not improbable supposition, that at some time or other we should have growing on this earth a plant of meteoric origin. At this particular stage of the debate (so we are informed by "The Western Morning News") some one attending the meeting of the Section introduced the Colorado Beetle, and this was held to be irresistibly funny; then someone else got up and said he was an Irishman, which was judged to be even funnier still. At length another speaker arose to breathe the hope that when Papa Colorado Beetle dropped down on a meteorite he would leave Mamma Colorado Beetle

behind, which was felt to be far and away the funniest thing of all. Some of the Associates, however—men who had not yet learned to know the length and depth of scientific "wit"—began to feel uneasy; and although a gallant effort appears at this juncture to have been made to win back their confidence by assuring them that meteorites really do not contain organic matter of any kind, the Section was not to be comforted till the telephone was set a-going But to return.

Nothing bearing the semblance of a plant or even of its seed has as yet been met with in a meteorite; nor have any of the masses which have fallen on our planet shown anything approaching the structure which distinguishes sedimentary rocks from those of a purely plutonic character. The occurrence, however, in them, or with them, of organic compounds, of compounds of carbon and hydrogen, which it is hard to suppose could owe their existence to any other agency than that of life itself, and which represent the final stage previous to their final destruction, has now been so frequently noticed that I have put together in chronological order what information in this direction from a "world ayont" the meteorites have brought to us.

1806. *March 15th*, 5 P.M.—Two stones, weighing together six kilogr., fell at Alais, Dép. du Gard, France. They have the appearance of an earthy variety of coal; the colour of the crust is a dull brownish-black, so is that of the interior. The structure is very soft and friable. When heated it emits a faint bituminous odour. It was examined at the time of its fall by Thénard and a Commission appointed by the Institute of France. The French observers found it to contain 2·5 per cent. of carbon; while Berzelius, in 1834 estimated the amount of carbon present to be 3·05 per cent. In 1862 Roscoe submitted this meteorite to a very thorough investigation. He found the carbon present to amount to 3·36 per cent. Ether dissolved 1·94 per cent. of the stone; the solution on evaporation left crystals which have an aromatic odour, and a fusing-point of 114° C., and which sublime on the application of heat, leaving a slight carbonaceous residue. The crystals really appear to be of two kinds: *acicular* crystals, which are sparingly soluble in absolute alcohol, but are readily taken up by ether, carbon disulphide, turpentine, and cold nitric acid, and dissolve in cold sulphuric acid, striking a brown colour; and *rhombic* crystals, which dissolve in ether and carbon disulphide, but are unaffected by cold nitric acid, sulphuric acid, or turpentine. An analysis of 0·0078 gramme of the crystals soluble in alcohol gave the following numbers:—

Sulphurous acid .	0.010	Sulphur . . .	0·005
Carbonic acid . .	0·008	Carbon . . .	0·0022
Water . . .	0·003	Hydrogen . . .	0·0003

The atomic ratio of carbon to hydrogen, then, is nearly 1 : 1, or that of the reddish-brown and colourless mineral resin könleinite, which occurs in crystalline plates and grains in the lignite of Uznach, in Switzerland. Kraus makes the fusing-point of könleinite 114° C.; it is slightly soluble in alcohol, but much more soluble in ether. Dr. Lawrence Smith, who has recently examined the Alais meteorite, arrives at the same results as Roscoe; and also that the carbonaceous ingredient of this meteorite resembles in all its physical characters those of a substance which he obtained from the graphite of the Sevier-County meteoric iron, to which I shall presently refer.

1838. *October* 13*th*, 9 A.M.—At the hour mentioned a great number of large stones fell over a considerable area at Kold-Bokkeveld, seventy miles from Cape Town. Those which fell near Tulbagh are estimated to have weighed many hundredweights. It is said that they were soft when they fell, but became hard after a time. This material has a dull black colour, and is very porous and friable. Harris, who analysed it in 1859, determined the presence of 1·67 per cent. of carbon, and somewhat more than 0·25 per cent. of an organic substance soluble in alcohol. This compound is described as possessing a yellow colour, and a soft resinous, or waxy, aspect. It readily fused with a slight rise of temperature, and when heated in a tube it was decomposed, emitting a strong bituminous odour, and leaving a carbonaceous residue. Some four years ago I was considering what should be done with a trace of this substance, so small in amount that it could not be removed from the vessel containing it. I was unwilling to throw away even so small a quantity of so precious a substance, so I drew off the neck of the flask and placed it in a dark cupboard of a room, the temperature of which, during the greater part of the year, is unusually high. In the interval this organic compound has sublimed, and is deposited on the higher parts of the vessel in colourless and well-defined crystalline plates.

1840.—During this year a large mass of meteoric iron was discovered in Sevier County, Tennessee, enclosing a large nodule of graphite. "It is," writes Dr. Lawrence Smith, "the largest mass of graphite which has come under my observation, and is perhaps the largest known." Its dimensions are 60 mm by 20 mm and 35 mm, and it weighs 92 grammes. Two grammes of this nodule were reduced to powder and treated with ether, and the liquid on evaporation left a residue weighing 15 milligrammes, and possessing an aromatic, somewhat alliaceous, odour. It consisted of long colourless acicular crystals, others which were shorter, as well as some rhomboidal crystals and rounded particles. This extracted substance melted at about 120°C. When heated in a tube closed at one end it melts and

then volatilizes, condensing in yellow drops, and leaving a carbonaceous residue. Dr. Lawrence Smith believes that the three elements, carbon, hydrogen, and sulphur, which they contain, may be in combination, and he has named the meteoric sulphohydrocarbon "celestialite."

1857. *April 15th*, 10.11 P.M.—A brilliant detonating meteor was observed at this hour over Kaba, S.W. of Debreczin, Hungary, and a meteorite weighing 4 kilogr. was found on the following morning imbedded in the hard surface of a road close by. The crust is black, and the mass of the stone dark grey; throughout the structure black portions of the size of peas lie scattered, giving the stone a porphyritic character. Wöhler treated the stone with alcohol, which removed a white, apparently crystalline, substance possessing a peculiar aromatic odour. With ether it broke up into oily drops, and appeared to be decomposed into an insoluble fluid body and a soluble solid portion. The solid substance was obtained in a distinctly crystalline condition on driving off the ether. It volatilizes in air, fuses in a closed tube, and is decomposed when greater heat is applied, a fatty odour being observed, and a black residue left. The hydrocarbon is believed by Wöhler to be allied to ozocerite or scheererite. When the powdered stone is heated in oxygen it turns of a cinnamon-brown colour. This meteorite contains 0·58 per cent. of carbon.

1861.—The huge mass of meteoric iron discovered at Cranboune, near Melbourne, Australia, in 1861, encloses more or less rounded masses of carbon. They are pronounced by Berthelot, who has submitted some of the material to the most powerful oxidizing reagents, to resemble the form of carbon which separates from cast-iron on cooling rather than native graphite.

1864. *May 14th*, 8 P.M.—On this occasion more than twenty stones fell at Montauban, Tarn et Garonne, France, some of them being as large as a human head, and most of them smaller than a fist. The appearance which this meteorite exhibits closely resembles that of a dull-coloured earthy lignite. The masses are black and very friable, and fall to powder when placed in water; this is due to the removal of the soluble salts which cement the ingredients together. A shower of rain would have destroyed them. One hundred parts of this stone contain 5·92 parts of carbon itself, partly as a constituent of one organic compound, which Cloëz found to possess the following composition:—

Carbon	63·45
Hydrogen	5·98
Oxygen	30·57
	100·00

Berthelot endeavoured to reconstruct the body of which this is a decomposed product by means of hydriodic acid, and

obtained a considerable quantity of the hydrocarbon $C_{2n}H_{2n+2}$ analogous to rock-oil. The reduction takes place less readily in this case than in that of coal. Dr. Lawrence Smith finds the combustible portion of the material to amount to about 4·5 per cent.

1867.—This Indian meteorite, which fell at Goalpara about the year 1867 (the exact date is not known), was examined by Tschermak, who found it to contain 0·85 per cent. of a hydrocarbon. The quantity, though small, materially affects the general appearance of the stone; it can be recognized under the microscope as a smoky-brown, lustreless ingredient accompanying the fragments of nickel-iron. Of the 0·85 per cent. 0·72 is carbon and 0·13 hydrogen. Tschermak suggests that the luminous phenomena so often attending the fall of an aerolite and the "tail" left by many meteors and shooting stars may be due to the combustion of compounds of which carbon forms an important constituent.

1868. *July 11th.*—The curious meteorite of dull grey hue and loose structure which fell on this day at Ornans, Doubs, France, partly owes its dark colour to the presence of a hydrocarbon.

1869. *January 1st*, 12.20 P.M.—A most remarkable fall of stones took place on New Year's Day, 1869, at Hessle, near Upsala; it is the first aerolitic shower recorded to have taken place in Sweden. The meteorites have so loose a structure that they break in pieces when thrown with the hand against the floor or frozen ground. The most interesting feature of the Hessle fall is the association with the stones referred to of matter mainly composed of carbon. The peasants of Hessle noticed that some of the meteorites which fell on the snow near Arnö soon crumbled to a blackish-brown powder resembling coffee-grounds. Similar powder was found on the ice at Hafslaviken in masses as large as the hand, which floated on water like foam, and could not be held between the fingers. A small amount secured for examination was found under the microscope to be composed of small spherules; it contained particles extractible by the magnet, and when ignited left a reddish-brown ash. Heated in a closed tube it gave a small brown distillate. A quantity dried at 110°C. possessed the following composition:—

Carbon	51·6
Hydrogen	3·8
Oxygen (calculated)	15·7
Silicic acid	16·7
Iron protoxide	8·4
Magnesia	1·5
Lime	0·8
Soda and Lithia	1·5
	100·0

The combustible ingredient appears to have the composition $n\,C_9H_4O_2$. It was noticed on this occasion that the stones found in the same district with the carbonaceous substance, were, as a rule, quite round and covered on all sides with a black, dull, and often almost sponge-like, crust. The iron particles on the surface of the smaller stones were usually quite bright and unoxidized, as though the stone had been heated in a reducing atmosphere. Nordenskjöld, who examined them, expresses the belief that this carbon compound frequently, perhaps invariably, occurs in association with the meteorites, and he attributes its preservation in this case to the fall of the stones on snow-covered ground.

1870.—During this year the Swedish Arctic Expedition discovered in the basalt of Ovifak, near Godhavn, Island of Disko, Greenland, some enormous metallic masses which are generally regarded as blocks of meteoric iron. Like meteoric iron, they contain nickel and cobalt, but, unlike that iron, they are but slightly attacked by hydrochloric acid. The metal, moreover, when heated evolves more than 100 times its volume of a gas which burns with a pale blue flame, and is carbonic oxide mixed with a little carbonic acid; after this treatment the substance dissolves in acid, leaving a carbonaceous residue. The composition of this remarkable "iron," if we may call it by that name, has been found by Wöhler to be as follows:—

Iron	80·64
Nickel	1·19
Cobalt	0·49
Phosphorus	0·15
Sulphur	2·82
Carbon	3·67
Oxygen	11·09
	100·05

It appears to be a mixture of about 40 per cent. of magnetite with metallic iron, its carbide, sulphide, and phosphide, and its alloys of nickel and cobalt, as well as some pure carbon in isolated particles.

From all this we see though there is not a particle of evidence to prove the persistence of living germs on meteorites during their passage through our atmosphere, it is quite clear that the cosmical bodies, whatever they may have been, from which our meteorites were derived, may very probably have borne on their surface some forms of organized beings.

One objection which appears to have been raised to Sir William Thomson's theory was to the effect that germs could not exist without air; another that the low temperature to

which they would be exposed before entering our atmosphere would suffice to destroy life. Micheli, in his valuable *Coup d'œil sur les principales publications de Physiologie végétale*, refers to the researches of Uloth,* who found that twenty-four species of plants which had been placed in a cave in the centre of a glacier germinated after the lapse of six weeks. *Lepidium ruderale* and *sativum*, *Sinapis alba*, and *Brassica Napus*, had germinated; and at the close of four months other crucifers and some grasses and leguminous plants had germinated also. Haberlandt found that of a number of seeds which had been exposed for four months to a temperature of 0° to 10° the following species flourished: rye, hemp, vetch, pea, mustard, camelina, two species of clover, and lucerne. The influence of the withdrawal of air from seeds on their power of germination has also been studied by Haberlandt. He found that seeds after they had been placed *in vacuo* germinated as usual. A slight retardation was noticed in the case of the seeds of the oat, the beetroot, and a bean, which appear to require the air contained in their tissues. In three experiments 58, 32, and 40 per cent. of the seeds germinated.

* "Flora," 1875, No. 17.

REVIEWS.

SCEPTICISM IN GEOLOGY.*

THIS is a well-written little book, and is explanatory of its author's doubts regarding the doctrines of uniformity and continuity as elaborated by Lyell and Geikie. It "does not deal with the great and incontrovertible *truths* of Geology, but only with certain excrescences, which aim at proving the earth to have been fashioned by mechanical processes still going on." The author anticipates "rough usage" from certain quarters, but submits that the long array of his facts, together with his answers and objections to alleged facts, cannot be refuted. The criticisms of the author relate, he states, to "uniformity, or the operation of modern causes; the elevating power of earthquakes; erosion of rocks by rivers; unlimited denudation by atmospheric denudation, and the antiquity of man on the earth." He suggests that "enormous exaggerations have paved the way for erroneous conclusions, and that supposed analogy has been mistaken for evidence." After claiming the right to doubt, and stating the value of doubting in science, the author informs his readers that he has studied the writings of the dominant school, and investigated the earth's structure in this and other countries himself. The liberty of doubting is pleaded for rather unnecessarily, for if any set of men doubt, criticize, and protest against dogmatic authority, it is that of the modern school of Geology; and if the author had come amongst them, listened to the debates of the Geological Society, and read the current literature of the science during the last few years, he would have found that most of his crotchets are out of date, and that Lyell and Geikie—an antithetic combination of genius and common-place—are not so much followed as he imagines. Should he read the address of the present President of the Geological Society, he will find therein the generally accepted limitation of the Huttonian doctrine, and a protest against the dogma that the forces of old acted continuously in the same degree. It is not fair on the part of the author to saddle geology with a theory because it emanates from a man who has "written a book;" and if he had made the slightest inquiry among the professors of Geology in England, or had mixed amongst the rising school, he would have heard such a dictum as the following: "It is evident that the great mountain chains of the world are due in the first place to upheaval," very much derided. The

* "Scepticism in Geology." By Verifier. 8vo. London: John Murray. 1877.

least knowledge of geological theory would have saved our critic from the trouble of antagonizing the notion that mountain formation and that of the volcano are identical or analogous. Lyell stated that there is an intimate connection between the two classes of phenomena; and Elie de Beaumont, at least forty years ago, attributed mountain formation not to partial volcanic action, or a reiteration of ordinary earthquakes, but to the secular refrigeration of the entire planet. Dana, Mallet, and all advanced teachers, follow this theory. The author demurs to the present rise of land. There is no doubt that whilst there is evidence of the rise of land in Scandinavia during the post-glacial and during the historic period, it is not a continuous operation; but the fact that there is no positive evidence of the rise of land in Sweden at this moment does not militate against the well-observed facts cited by Lyell. All evidence is not of the demonstrative kind; if it were science would be dark enough; but there is truth in the Butlerian axiom that probable evidence may approach demonstrable and even moral certainty. With regard to rivers cutting down gorges in rocks, the author states that they cannot do it, and that they did not do it, the river course being the result of cracks, faults, and fissures. He protests against the limestone cliffs of Yorkshire and Derbyshire being created by "watery erosion." Now, supposing that he knows the difference made by geologists between cliffs and escarpments, he need not be astonished at being told that inland cliffs are not believed by geologists to be produced by watery erosion; and, indeed, he will find it taught that many deep valleys are in lines of fault, many in great cracks, without relative tangible displacement of the strata; and that the initiatory condition of some profound cañons was a fissure. With regard to the non-erosive power of running water and its contained sediment both sideways and downwards, it belongs to the ideas of the paradoxers who do not yet revere the name of De Morgan. There are some people who will not see what others can. Amongst other paradoxes, the author tells us that the mud carried down by rivers is no proof of their erosive power.

The theory of sub-aerial denudation is a terrible trial of our author's faith; and because Stonehenge is where it was, and the turf lies and daisies flourish at the same level, century after century, in spite of wear and tear, therefore mountain outlines, valleys, and all the details of the physiographer, are not the result of the elements. This is a very old objection, but it is worth nothing; for whilst grass-covered spots last longer, others go with great rapidity, are worn down, furrowed, and make up the mud for the river and the sea. The evident accomplishments of the author of this work, his equally evident want of knowledge of the geology of the day, and his pinning his faith to "Manuals," are explanatory to a certain degree of his views, and of their appearing in print; but the real cause comes out in the last sentence. There we find the rattle in the tail; there the theological serpent, wise and even dove-like, shows its crest. Thus the author concludes: "The hunger of the mind to see every natural occurrence resting upon a cause, and the vanity of believing that modern science can account for and explain everything, appear to create in the scientific mind a stubborn resistance to the belief in a *First Cause*." This is not very consequent, and indeed is a gross mistake, to say the least: it is an unworthy

libel on a great number of men who probably have less anthropormorphic, but really nobler and grander ideas of the Creator of all things than "Verifier." Finally, we read, "It will eventually be acknowledged that, at the time and in the process of fashioning the globe, a power was exerted totally different from the present course of nature." We do not think that this prophecy will be fulfilled; on the contrary, we believe that the persistence of the influence of the primitive energies is true, and characteristic of the infinite wisdom which in the moral government of the world taught man not to bear false witness against his neighbour.

DERBYSHIRE IN PREHISTORIC TIMES.*

AS the circle of the sciences continues to enlarge, it comes in contact with subjects which were formerly considered to lie far outside its pale. Scientific methods are now-a-days applied to history, to mythology, and to almost all archæological subjects. Everything that relates to man in the past, when treated scientifically, is in fact fairly claimed as material for anthropological study. And the wholesome effect of this has been well seen in our increased knowledge of the early history of our own islands. The old-fashioned type of antiquary who was wont to attribute everything to the Romans is not, it is true, extinct, but he is certainly becoming rare. Geologists and craniologists have worked hand in hand with the archæologist, and their combined labours have been fraught with excellent results. Bone caves have been explored, and barrows have been opened, and an entirely new light has been thus shed upon the history of our "rude forefathers."

Mr. Rooke Pennington is an enthusiastic explorer of the prehistoric antiquities of the Derbyshire Peak, and takes much interest in the little museum at Castleton. In preparing a catalogue of the archæological part of this museum, he was led to jot down some notes on local antiquities, and these notes have grown into the volume before us.

Derbyshire has been rich in antiquarian explorers, among whom we may mention the names of Bateman, Carrington, and Llewellyn Jewitt. But there is plenty of room everywhere for those who really wish to assist in the interpretation of that mysterious Past which speaks only in the language of a flint arrow, or a bronze dagger, or a rude urn. Mr. Pennington has consequently been able to add something to our knowledge of this Past by his exploration of some of the barrows and caves in which Derbyshire abounds.

Both *long* barrows and *round* barrows are found in Derbyshire; and the former, we presume, are, as elsewhere, the more ancient. The long barrows formed the resting-place of a prehistoric race with marked dolichocephaly; and the Derbyshire tumuli thus conform to the famous anthropological dictum, "Long barrows and long heads; round barrows and round heads." The round or bowl-shaped barrows contain both burnt and contracted

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* "Notes on the Barrows and Bone Caves of Derbyshire: with an Account of a Descent into Elden Hole." By Rooke Pennington, B.A., LL.B., F.G.S. 8vo. London: Macmillan & Co. 1877.

burials, while the accompanying objects may be either of bronze or of stone, or of both materials. Our author has carefully analysed the results which were obtained by Bateman in his ten years' diggings, and has failed to detect any rule of association. The men of the neolithic and of the bronze age appear to have had the same customs, whatever ethnic differences may have distinguished them. We need hardly say that this conclusion runs counter to the opinion of most archæologists, such as Sir John Lubbock, who believe that, as a rule, cremation was practised in the bronze age, and that in neolithic times the body was buried in a contracted posture.

Cave-hunting forms an interesting part of Mr. Pennington's book. It was he who first called attention to the fissures in the Windy Knoll Quarry, which have yielded so rich an assemblage of pleistocene remains. From these fossils it is clear that herds of bison and reindeer must have roamed over the hills of Derbyshire in the pleistocene period, perhaps towards its close; or, as our author suggests with some vagueness, in "the late geological time." Professor Boyd Dawkins has studied this fauna, as also that from the Creswell Caves, which have been so carefully explored by the Rev. Magens Mello.* The Creswell fauna included the mammoth, the woolly rhinoceros, the cave hyæna, and the terrible sabre-toothed machairodus. With this assemblage of extinct animals, man must have lived—man in a state unquestionably savage, yet with some dawning desire for art. In fact, one of the most interesting relics of prehistoric man which have been found in any part of the country is a piece of bone from Robin Hood Cave, incised with the well-defined outline of the horse of the period.

So much indifference is often displayed by the inhabitants of a district to their local antiquities, that all enthusiastic exploration of this kind deserves encouragement. We only regret that Mr. Pennington did not see his way to illustrating his descriptions by a few engravings.

THE RECORD OF GEOLOGICAL LITERATURE.†

IN the early part of last year we noticed the appearance of the first "Geological Record," containing an account of the literature of geology and the affiliated sciences published in the year 1874. The second "Record," giving the analysis of the geological publications for 1875, is only just published, its appearance having been delayed in part by the occurrence of a fire at the printers', which, without absolutely destroying any portion of the work, threw obstacles in the way of its completion.

In our former notice we stated that this series of annual volumes, if carried out, would prove a most valuable aid to the geologist, and the appearance of the second issue only serves to confirm and widen this opinion. In the new volume several improvements are introduced—some in the typographical execution of the work, to render it more easy to consult; one in the general arrangement, namely, the introduction of a heading "Oceania" for

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* See an Article by Mr. Mello in our present number.

† "The Geological Record for 1875: an Account of Works on Geology, Mineralogy, and Palæontology, published during the year." Edited by William Whitaker, B.A., F.G.S. 8vo. London: Taylor & Francis. 1877.

those islands which do not readily admit of being grouped under other geographical categories: i.e. besides the Pacific Islands, to which the term is usually applied, such isolated spots of land as St. Helena, St. Paul, and Amsterdam island, but also including, erroneously it seems to us, such islands as Formosa, Japan, Sumatra, and Borneo, which the ordinary reader would certainly look for under the head of Asia; and, most important of all, the addition of a classified index of new species to the section devoted to palæontological contributions. To the working palæontologist this index will be an inestimable boon. It is classified only as far as the great zoological groups generally called classes, and under each of these the species are arranged in the alphabetical order of their generic names, so that all the difficulty that might easily arise from the adoption of a classification in more detail is avoided, and the palæontological student has merely to run down a column or two of names to see whether there is in the volume any record of a new fossil in which he may be interested.

The present volume is considerably larger than its predecessor, and includes, with the supplement for the year 1874, no fewer than 2,350 entries of papers and separate works published. The labour of preparing all these notices, most of which include a brief statement of the general contents or bearings of the works referred to, must have been very great, and the thanks of all geologists are due to Mr. Whitaker, the editor, and his staff of assistants, for carrying cut to a successful issue so arduous an undertaking. We can only echo Mr. Whitaker's hope that the number of subscribers will increase sufficiently to enable him for many years to continue and even extend his valuable labours.

DIFFERENT FORMS OF FLOWERS.*

IT is a curious coincidence (though perhaps not without its appropriateness) that the grandson of Erasmus Darwin should be the great authority on what we may venture to call the "prohibited degrees of relationship" among plants. To the older naturalist it was an easy matter to discourse poetically upon the phenomena of the fertilization of plants, then but little known except to the professed botanist; but he might have felt his genius trammelled had he known anything of the wonderful series of restrictions upon indiscriminate fecundity which the persevering researches of his great descendant have brought to light.

In two numbers of this Review published during the present year we have had occasion to notice the appearance of works from Mr. Darwin's hand bearing upon this subject, namely, an original treatise upon "the effects of cross and self-fertilization in the vegetable kingdom," in which the general evidence from which it may be inferred that cross-fertilization is to be regarded as a necessary process, even in the case of hermaphrodite flowers, is brought forward; and a second edition of the wonderful book in which the cross-fertilization of the orchids is described. We have now before us a third volume, the contents of which scarcely yield in interest to those of

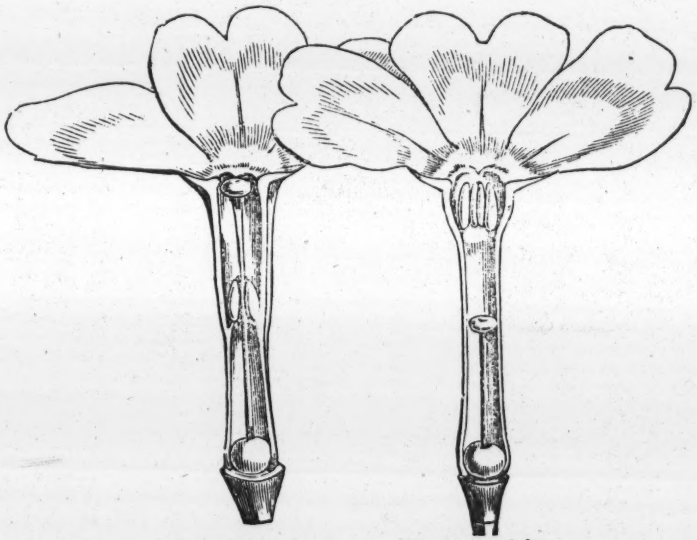
* "The Different Forms of Flowers on Plants of the Same Species." By Charles Darwin, M.A., F.R.S. 8vo. London: John Murray. 1877.

the second work above-mentioned, namely, the description of the different forms of flowers which occur on plants of the same species, with a discussion of the purpose served in Nature by these curious and sometimes complex arrangements.

The phenomena discussed in this volume have attracted Mr. Darwin's attention for many years, and very soon after the first publication of his "Origin of Species" (namely, in 1862) he communicated to the Linnean Society his first paper on the subject, which related to the dimorphism of the flowers in the genus *Primula*. Other papers followed on phenomena of the same order occurring in the genera *Lythrum* and *Linum*, and these constitute the foundation of a portion of the present work, in which, however, the author has added his own more recent observations upon other plants, and supplemented his personal work with information derived from many trustworthy sources. The whole constitutes a most interesting record of facts and inductions of great scientific importance; and the popular interest of the book is enhanced by the facility with which many of the observations may be repeated, so that anyone who has a garden and a magnifying-glass may with ease enter upon a course of practical investigation under the best possible guidance.

Mr. Darwin's first published researches related to certain species of the genus *Primula*, in the cultivated forms of which known as the polyanthus

FIG. 1.



Long-styled form. Short-styled form.

TWO FORMS OF FLOWERS OF THE COWSLIP (*Primula veris*), enlarged.*
The floral envelopes on the near side removed.

and the auricula florists have long been familiar with two kinds of flowers, which they denominate "pin-eyed" and "thrum-eyed." In the common cowslip (*P. veris*) this difference between the two forms is sufficiently remarkable (see Fig. 1.) In the "pin-eyed" plants the style is much elongated, so as to carry the nearly globular and rough stigma right up into the throat of

* For the loan of this and the following figures, we are indebted to the kindness of Mr. John Murray.

the flower, where it stands, like the head of a pin, far above the level of the anthers, which spring from the interior of the tube about half-way down. In the "thrum-eyed" plants, on the contrary, the anthers are placed quite in the throat of the flower; and the style, which is much shorter than in the preceding form, only carries the somewhat flattened and much smoother stigma about half-way up the tube of the corolla. In other words, the relative positions of the anthers and stigmas in the two forms are as nearly as possible reversed. For this difference in structure Professor Hildebrand long since proposed the term "heterostyled," which Mr. Darwin retains in the present work, although he gives the preference—justly, as it seems to us—to the term "heterogonous" proposed by Dr. Asa Gray, to express the same condition of the reproductive parts.

There are certain other differences in the two forms. Thus the long-styled plants have the pollen-grains smaller than those of the short-styled, and of an oblong form, whilst the pollen of the short-styled plants is nearly spherical; and further, the long-styled flowers have larger ovules and produce fewer seeds than their short-styled fellows. The two forms of flowers never occur upon the same plant, and the long-styled flowers seem to open a little earlier than the short-styled. The short-styled flowers are more fertile than the long-styled, the proportion of seed produced being by weight nearly as four to three.

To ascertain the meaning of these curious phenomena, which he naturally believed to point towards cross-fertilization, Mr. Darwin instituted a series of experiments on the cowslip, the results of which are very interesting. He covered with net six plants of the short-styled and eighteen of the long-styled form, and found that they produced respectively twenty-four and seventy-four umbels of flowers. The six short-styled plants furnished altogether about fifty seeds, weighing 1·3 grain, but not a single seed was produced by the eighteen long-styled cowslips. "Judging from the exposed plants which grew all round in the same bed," says Mr. Darwin, "and had been treated in the same manner, excepting that they had been exposed to the visits of insects, the above six short-styled plants ought to have produced ninety-two grains' weight instead of only 1·3; and the eighteen long-styled plants, which produced not one seed, ought to have produced above two hundred grains' weight. The production of a few seeds by the short-styled plants was probably due to the action of Thrips, or of some other minute insect."

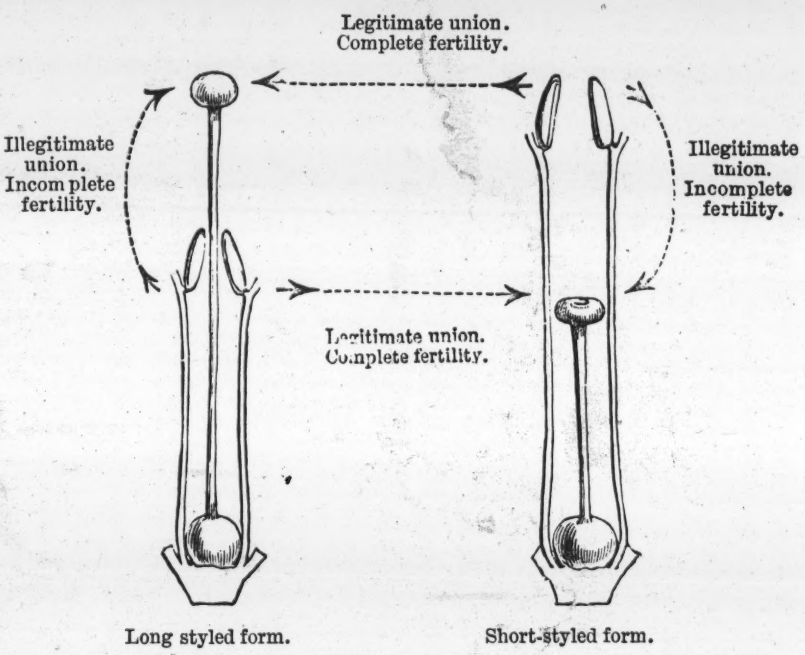
Thus we have insects again brought in as the marriage-priests of plants; and, considering the arrangement of the parts, as already described, in the cowslip, it is easy to see in what manner the visits of insects to the flowers are made available for this purpose. The flowers of the cowslip and of other species of *Primula* secrete an abundance of nectar, and bees and moths may be seen visiting them in search of this sweet food. Mr. Darwin records his observation of two species of humble-bees sucking out the nectar in a legitimate manner by inserting their trunks through the throat of the flower; Mr. H. Müller has seen an *Anthophora* and a *Bombylius* similarly engaged; and one of Mr. Darwin's sons caught *Cucullia verbasci* in the act. There is, indeed, no doubt that insects visit these flowers, and the mode in which their agency is made subservient to the fertilization of the different forms is

explained as follows by Mr. Darwin:—"The pollen," he says, "adheres to any thin object which is inserted into a flower. The anthers in the one form stand nearly, but not exactly, on a level with the stigma of the other; for the distance between the anthers and stigma in the short-styled form is greater than that in the long-styled, in the ratio of 100 to 90. This difference is the result of the anthers in the long-styled form standing rather higher in the tube than does the stigma in the short-styled, and this favours their pollen being deposited on it. It follows from the position of the organs that if the proboscis of a dead humble-bee, or a thick bristle or rough needle, be pushed down the corolla, first of one form and then of the other, as an insect would do in visiting the two forms growing mingled together, pollen from the long-stamened form adheres round the base of the object, and is left with certainty on the stigma of the long-styled form; whilst pollen from the short stamens of the long-styled form adheres a little way above the extremity of the object, and some is generally left on the stigma of the other form." That the two kinds of pollen are thus segregated in Nature was proved by microscopic examination of that adhering to the proboscides of the humble-bees and moth caught in the act of visiting the flowers, "and thus," says Mr. Darwin, "pollen will be regularly carried from the one form to the other, and they will reciprocally fertilize one another." Nevertheless, the pollen may occasionally reach the stigma even of the flower in which it was produced, and this seems to be especially the case with the short-styled form, in which Mr. Darwin found that when he "inserted a bristle or other such object into the corolla of this form, and had, therefore, to pass it down between the anthers seated round the mouth of the corolla, some pollen was almost invariably carried down and left on the stigma." By this means, and also by the visits of minute insects, such as Thrips, crawling into the tube of the flowers, a certain amount of self-impregnation is therefore possible; and indeed Mr. Darwin supposes this to have taken place in his early experiments in covering these plants, when, as already stated, the short-styled individuals produced a minute quantity of seed.

By a series of experiments in the fertilization of the stigmas of the two kinds of flowers by pollen from flowers of their own and of the opposite form, Mr. Darwin arrived at results which show clearly enough that the purpose of this peculiar arrangement of the parts is the assurance of cross-fertilization. He says "four essentially different unions are possible; namely, the fertilization of the stigma of the long-styled form by its own-form pollen, and by that of the short-styled; and the stigma of the short-styled form by its own-form pollen, and by that of the long-styled," the fecundation of the stigma by its own-form pollen being regarded by Mr. Darwin as an "illegitimate union," and by that of the other form as a "legitimate union," in accordance with the hypothesis which he had formed (see fig. 2). The tables showing the results of his experiments bear out his prevision in a remarkable manner. From them it appears that in the "legitimate" unions 77 per cent., in the "illegitimate" only 45 per cent. of the flowers fertilized produced capsules; 92·6 per cent. of the former and only 69 per cent. of the latter being what Mr. Darwin calls good capsules; that is to say, capsules containing more than one or two seeds; and the superior

fertility of the "legitimate" unions becomes still more striking when we find that the average weight of seed in good capsules from legitimate and illegitimate unions is as 54 to 35. Thus in this first series of experiments—the results of which, however, are perhaps a little below the average—the fertility of the legitimate and illegitimate unions, as shown by percentage

FIG. 2.



THE STAMENS AND PISTILS OF THE TWO FORMS OF COWSLIP, SHOWING THE FOUR POSSIBLE UNIONS OF THE POLLEN WITH THE STIGMAS.

results, in weight of seeds, would seem to stand approximately in the proportion of 38 to 11; or, in other words, the legitimate unions are 3½ times as prolific as the illegitimate ones.

The inference from these facts appears quite plain—the peculiar arrangement of the parts in the flowers of the cowslip is manifestly intended to insure the occurrence of cross-fertilization. The general facts must have been well-known to botanists for many years, seeing that the distinction of "pin-eyed" and "thrum-eyed" polyanthuses has long been recognized by florists; but their interpretation was a more difficult matter, and could only arise from considerations such as those put forward by Mr. Darwin in support of his much-maligned theory of evolution. As he says, we have here a case to which no parallel was known to exist in the vegetable, or indeed in the animal kingdom, for in this case the individual plants "are divided into two sets or bodies, which cannot be called distinct sexes, for both are hermaphrodites; yet they are to a certain extent sexually distinct, for they require reciprocal union for perfect fertility." But the clue once gained, the phenomena were soon found to be not at all isolated; and the researches of Mr. Darwin himself and of other observers have now brought to light a number of plants in which the same sort of dimorphism prevails. A majority of the species of *Primula*, certain species of *Linum*, several

rubiaceous plants, and some others, are found to exhibit similar characters; and these cases are all described in the work before us.

Fig. 3.

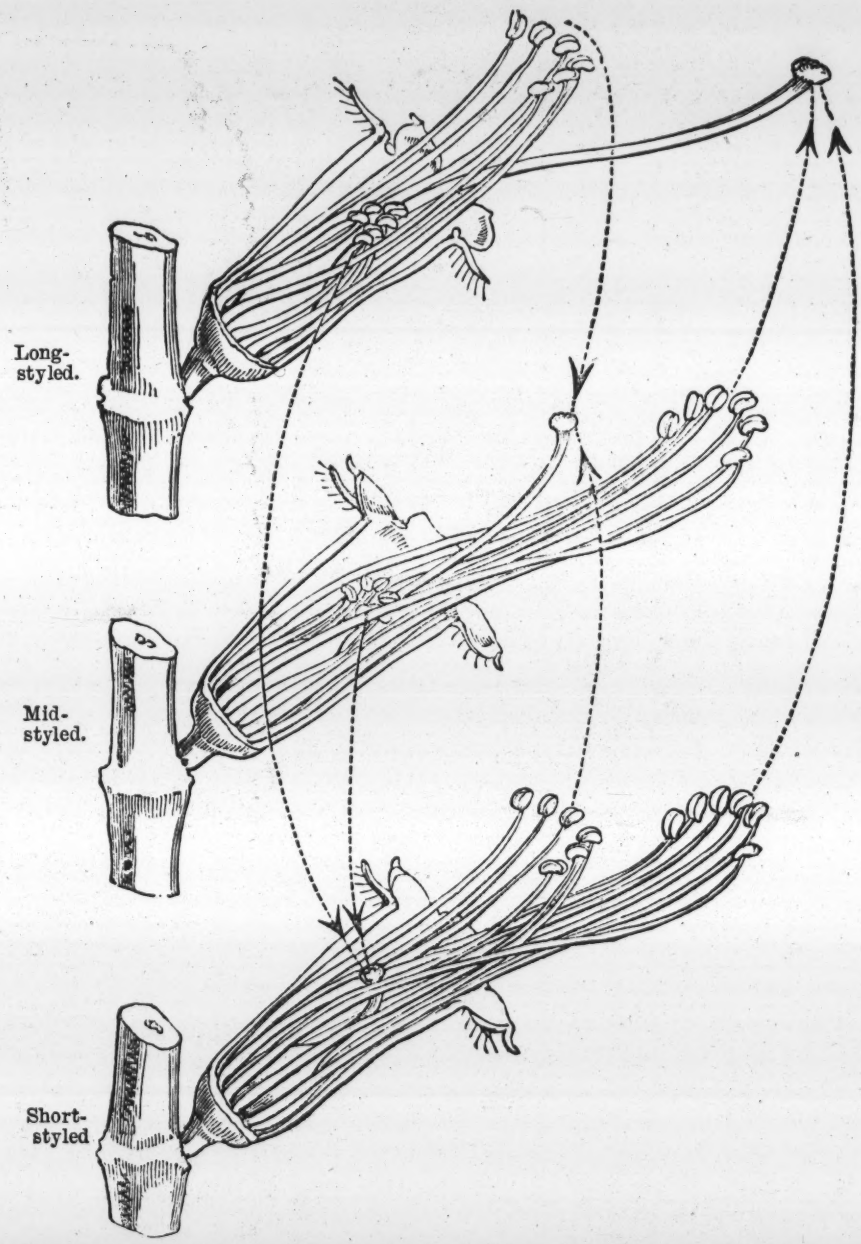


DIAGRAM OF THE FLOWERS OF THE THREE FORMS OF *Lythrum salicaria*, IN THEIR NATURAL POSITION, WITH THE PETALS AND CALYX REMOVED ON THE NEAR SIDE. ENLARGED SIX TIMES.

The dotted lines with arrow-heads show the direction in which the pollen must be carried to each stigma to insure full fertility.

The discovery of still more complex sexual arrangements in the Purple Loosestrife (*Lythrum salicaria*) was made by Mr. Darwin and described by him, soon after the publication of his observations on the

Primulaceæ. In this plant the flowers are trimorphic ; that is to say, they exhibit three different proportions of the style and stamens. We have *long-styled*, *mid-styled*, and *short-styled* flowers, and each of these forms contains stamens of two different lengths (see fig. 3). In the long-styled form the style projects far beyond the six long stamens, which are of middle length, corresponding in this respect with the pistil of the mid-styled form, and protrude, with the style, from the mouth of the flower; within the flower are six short stamens. In the mid-styled flowers the six long stamens are about as long as the style in the long-styled form, with the longest stamens in which the style corresponds in length, and the short stamens are again enclosed within the calyx. The short-styled flowers have the pistil entirely concealed within the flower, whilst both sets of stamens project from its opening and are respectively of the length of the longest stamens in the other two forms. By a series of experiments, far too complicated for us to attempt to give any account of them here, Mr. Darwin ascertained that the pollen from each of the three kinds of stamens is destined to fertilize the pistil of corresponding length ; the fertility of the legitimate unions on this principle, "as judged by the proportion of the fertilized flowers which yielded capsules, is as 100 to 33; and judged by the average number of seeds per capsule as 100 to 46." But taking the average number of seeds per flower fertilized, the proportional fertility is as 71·89 to 11·03. As Mr. Darwin indicates, the peculiar arrangements of the parts in this plant also are specially adapted to the requirements of fertilization by the agency of insects.

Several other trimorphic species are noticed here, and the details of experiments made upon them tabulated. The experiments and tables are necessarily of a somewhat complicated description, seeing that in the case of a trimorphic plant of this kind six legitimate and twelve illegitimate unions are possible, and all these had to be tried in order to get at reliable results.

Side by side with these elaborate provisions for securing cross-fertilization it is somewhat singular to find that in some species of plants there prevails a dimorphism which serve a directly opposite purpose. A considerable number of plants (Mr. Darwin here gives a list of fifty-five genera including them) bear what have been called cleistogamic flowers, which never open at all, are more or less imperfect in their structure, and yet bear an abundance of seed by a process of self-fertilization. The object of this peculiar arrangement, which may be observed in common species of *Viola*, in the woodsorrel, and many other well-known plants, is, according to the author, the production of "an abundant supply of seeds with little expenditure;" and he adds, "we can hardly doubt that they have had their structure modified and degraded for this special purpose; perfect flowers being still almost always produced, so as to allow of occasional cross-fertilization," which he has proved to be possible. In some instances, also, of which one is furnished by the pansy (*Viola tricolor*), there are two forms of flowers, one much more conspicuous than the other, and adapted to cross-fertilization by insects; whilst the smaller flowers, although not closed, like cleistogamic flowers, are more or less modified to insure self-fertilization. In these cases the two forms of flowers are produced upon distinct plants.

Mr. Darwin's researches upon what he calls the illegitimate offspring of

his dimorphic and trimorphic plants proved them to behave very much after the fashion of hybrids between distinct species; and this leads him to discuss the question of hybrids at some length, and more especially the hybrids of the species of *Primula*, which are numerous even in a state of nature. He also notices the peculiarities of monœcious, dicœcious, and polygamous plants, of which he maintains that, "as the separation of the sexes would have been injurious, had not pollen been already transported habitually by insects or by the wind from flower to flower, we may assume that the process of separation did not commence, and was not completed, for the sake of the advantages to be gained by cross-fertilization. The sole motive for the separation of the sexes," he adds, "which occurs to me is, that the production of a great number of seeds might become superfluous to a plant under changed conditions of life; and it might then be highly beneficial to it that the same flower, or the same individual, should not have its vital powers taxed, under the struggle for life to which all organisms are subjected, by producing both pollen and seeds." This explanation is hardly satisfactory, and does not apply at all to monœcious plants. Among polygamous plants Mr. Darwin distinguishes a sub-class which he calls "gyno-dicœcious," in which the unisexual flowers are all females, and he says that they yield a much larger supply of seed than they would have done if they had all remained hermaphrodites—in other words, fewer stamens than would exist in the flowers if all were hermaphrodite are capable of producing sufficient pollen for all their pistils. This is probably true also of the ordinary monœcious and dicœcious plants, but still we cannot see where the necessary saving of material or powers comes in with sufficient force to account for phenomena of such importance. It must be borne in mind, however, that these suggestions of Mr. Darwin's are merely tentative, and that we have still much to learn before the "why and wherefore" of all these things is laid open to our view.

Nevertheless by works such as this, chiefly inspired by the new spirit thrown into natural-history research by the Darwinistic publications, we cannot doubt that progress is being made in the right direction. Any attempt at the explanation of phenomena is a step towards the truth; if it justifies itself it is absolutely an advance; if its justification be difficult, partial, or even impossible, the researches necessary for testing its value must in any case lead to valuable results. Even the steps taken apparently on the most indisputable grounds may open questions that it is very difficult to answer. Thus, to take the case of the Primulas, many species of which, as we have seen, seem to be specially organized so as to render cross-fertilization a necessity, we find, side by side with the "heterostyled" species, others which are "homostyled;" and it is hard to see, from the conditions of existence of the plants, why one set should be so peculiarly modified, and the other set left in what we may call a normal condition. So also with the monœcious and dicœcious plants in groups the flowers of which are normally hermaphrodite. These and many other matters of doubt, which may easily occur to the mind in studying Mr. Darwin's descriptions of the different forms of flowers, furnish objects of study which we recommend to the attention of our readers; they are points not very difficult of investigation under the guidance to be obtained from

the present book, and their investigation certainly possesses a much higher interest for the botanist than the mere collecting, drying, and naming of the plants of his district.

DUST.*

"PHILOSOPHERS have said that 'there is a reason, a meaning, and an end in Nature.' We Dusts require more than this—a proof of the reason, a result of the meaning, and a continuance of the end."

These are the opening words of Mr. Malet's preface to his "Incidents in the Biography of Dust," and we cannot but think that our readers would forgive us if, having read them, we had abstained from any further examination of the book. But, as Thackeray once hinted, there is a power of self-sacrifice in the editorial idiosyncracy, and we endeavoured to the best of our power to make out what the purpose of the little book might be. There used to be a phrase current (whether it is still extant we know not) which ran as follows: "Down with the dust;" and so far as we remember bore a signification not at all agreeable to the impecunious. Mr. Malet's watch-word is, "Up with the Dust," which would sound much pleasanter if we could only make out what "Dust" is. But this is precisely the puzzle before us.

In his first introductory chapter, which, we believe, gives in the form of aphorisms the principles of his theory, Mr. Malet tells us, in the first place, "that the earth consists of air, water, and dust." He then gives us the curious piece of information that "air is composed chiefly of oxygen, hydrogen, and carbonic acid gases;" and after telling us something about water proceeds to say that "the dry land of the earth is dust;" and then that "dust is now chiefly composed of everything that grew or lived on the earth, mixed with the dust from which all things were created." Here we seem to see a glimmer of light, and that by dusts may be signified the non-aeriform constituents of the world; but a little further on this comfort is taken from us, and we are told that "there are gaseous and non-gaseous dusts." In the next paragraph we learn that "everything that lived or grew was composed of air, water, and dust," which sounds like a return to the former conception; and then that "these three elements therefore compose the earth," so that dust is one of the elements; but when we turn to Chapter V., which is headed, "The Birth of Dust," and in which, therefore, we justly look for something conclusive, we find ourselves all abroad again. The author, in his playfully humorous style, writing himself down a Dust, tells us "that the dusts have nothing to do with the beginning." "It is far within the limit of that horizon that we look for the birth of our ancestors. Long previous to this event heaven and earth were created; the waters were divided by the firmament. Light and darkness made the day and night. The second day, that comprehensible measure of incomprehensible time, had passed away; two measures of eternity had run out; all

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* "Incidents in the Biography of Dust." By H. P. Malet. Small 8vo. London: Trübner & Co. 1877.

that was done in those measures was done by law. Those laws gave direct proof of supremacy; they were infallible; they have continued from eternity till now. The three elements affected by the laws—earth, air, water—were composed of and divisible into many parts; each part, and the whole, were amenable to the laws." Thus dust is an element, and earth is an element; but dust is not earth, for it is of later origin; and there are three elements, not four. Is not this "admirable fooling?"

As far as we can understand it, the author's geological theory, founded upon dust, is a Neptunian one, and he is in strong opposition to what he regards as the undue Plutonism of modern geologists. At the same time it must be observed that he considerably exaggerates the extent of this Plutonism; and, after the manner of his kind, quotes over-strong, and perhaps hasty statements of opinion on the part of individual geologists, as if they constituted the accepted body of geological science. In this process, being able to select his points of attack, he naturally sometimes gets the best of it; and he is evidently a firm believer in the Shandean principle, that when you demolish your opponent's theory you thereby establish your own.

In Mr. Malet's system of the earth "air and water are active, dust is the passive element." The sun is the sole cause of heat—its heat and the cold caused (he says "gained") by its absence produce the circulation of air and water. This circulation produces force, which acts on dusts, which are thereby moved on dry land and in the water. These movements cause subtractions on the surface and on the water bed, which are consequently lowered in places, and the surface of the water is therefore always sinking (?) and dust is left high and dry. The three following aphorisms are curious:—"Mountains are caused by the sinking of waters. The sinking of waters is due to the sun. Mountains are therefore due to the sun." And in other parts of his book the author ridicules the idea of mountains being thrown up by any forces of upheaval, whether by the ejection of materials from the interior of the earth or by the crumpling of the crust in shrinking. All "sinkings, landslips, subsidences, fractures, earthquakes," are caused by the removal of subterranean dusts by water. Further, there are combustible and incombustible dusts, which undergo pressure by the law of gravitation, and this pressure condenses dust. "Dust condenses heat. Heat acts on the dusts. Combustible dusts ignite; gases expand. Condensed sunlight is set free. Eruptions ensue." And you have an explanation of volcanic action. "The sun," adds Mr. Malet, "is the root of these phenomena. The root of the sun is the Creator. The earth is as it is, because the elements have not forsaken 'His laws.'" The last axiom probably contains the greatest truth in the book.

SCIENTIFIC SUMMARY.

ASTRONOMY.

DISCOVERY of Oxygen in the Sun.—Three interesting astronomical discoveries have been made during the past quarter. Undoubtedly the most important of these is the discovery of oxygen in the sun, by Dr. H. Draper, of New York. Although in some respects the discovery may be regarded as belonging rather to physics than to astronomy, yet its relation to the chief of all the bodies with which astronomy has to deal is too close to permit us to regard it as otherwise than astronomical.

Dr. Draper, who has been engaged now for several years in applying photography to the celestial bodies and their spectra (see our summary of astronomy for April last), in comparing the part of the solar spectrum between the lines G and H with the spectrum of air, finds that the oxygen lines are represented in the solar spectrum by bright lines. A well-marked quadruple oxygen line between wave lengths 4,345 and 4,350 coincides exactly with a bright group in the solar spectrum. This oxygen group alone is almost sufficient to prove the presence of oxygen in the sun, for not only does each of the four components have a representative in the solar spectrum, but the relative strength and the general aspect of the lines in each case is similar. On this point Dr. Draper remarks that he does not think sufficient stress has been laid on the general appearance of lines apart from their mere position; in photographic representations this point is very prominent. Several other coincidences are noted, leaving no room for doubt that oxygen exists in the sun in such a condition that its lines appear bright in the solar spectrum instead of dark like the lines of sodium, of iron, &c., and (usually) of hydrogen. As to the existence of nitrogen in the sun, there is not yet certainty. "Nevertheless," says Dr. Draper, "even by comparing the diffused nitrogen lines of the particular photograph" selected for showing the oxygen coincidences, "in which nitrogen has been sacrificed to get the best effect for oxygen, the character of the evidence appears. The triple band between 4,240, 4,227, if traced upward into the sun, has approximate representatives. Again, at 4,041 the same thing is seen, the solar bright line being especially marked. In another photograph the heavy line at 3,995, which in this picture is opposite an insufficiently exposed part of the solar spectrum, shows a comparison band in the sun." The bright lines of oxygen in the solar spectrum have not hitherto been perceived, probably from the fact that in eye observation bright lines on a less bright ground do not make the same impression on the mind as

dark lines on a bright background. When attention is called to their presence they are readily seen, even without the aid of a reference spectrum. But the photograph brings them into greater prominence.

"The discovery of oxygen and probably other non-metals in the sun," says Dr. Draper, "gives increased strength to the nebular hypothesis, because to many the absence of this important group has presented a considerable difficulty." He accompanies his paper with a new theory of the solar spectrum, which he considers we must no longer regard as merely a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapours, but as having also bright lines and bands superposed on the background of continuous spectrum. Such a conception not only opens the way to the discovery of others of the non-metals, sulphur, phosphorus, selenium, chlorine, bromine, iodine, fluorine, carbon, &c., but also may account for some of the so-called dark lines, by regarding them as intervals between bright lines.

New Star in Cygnus.—Second in importance only to the preceding, though probably it will be long before the true significance of the discovery is recognized, is the circumstance that the new star which blazed out last November in the constellation Cygnus seems to have faded into a nebula of the gaseous sort. "There is little doubt," says Lord Lindsay, in a letter to the "Times," "but that this star has changed into a planetary nebula of small angular diameter, giving a monochromatic spectrum when examined on Sept. 3, by means of a 15-inch refractor. The position of the star is R. A. 21 h. 36 m. 52 s.; N. Dec. 42° 16′ 53″; magnitude 10½, colour faint blue, near another star of the same size, rather red. A 5-inch telescope will render it visible; and the spectrum can be seen by means of a direct-vision prism outside the eyepiece. This would not be the place for speculating on the meaning of this most unexpected discovery, which indeed will require not only examination, but very careful examination and discussion, to educe its true significance. But without countenancing the statement that it is in direct opposition to the nebular hypothesis, we must admit that it runs directly counter to the theory that the planetary, or at any rate the gaseous nebulæ, are embryo suns.

Discovery of two Moons of Mars.—More interesting to the general public, because more readily intelligible, is the addition of two new satellites to the solar system, especially as these bodies are found in attendance on a planet which has long been regarded as moonless. On the night of Aug. 11, 1877, Professor Asaph Hall observed a small star near Mars, which was again observed on Aug. 16, when its motion was established by observation extending through an interval of two hours, during which the planet moved over thirty seconds of arc. On Aug. 17 this satellite was further watched, and an inner satellite detected, also by Professor Hall. On Saturday, Aug. 18, the discoveries were telegraphed to Alvan Clark & Sons, Cambridgeport, Mass., in order that if the weather should be cloudy at Washington, they might confirm the existence of the satellites with the 26-inch telescope for Mr. M'Cormick, now in their hands. The discovery was confirmed by Professor Pickering and his assistants at Cambridge, Mass., and also by the Messrs. Clark at Cambridgeport.

From the observations made up to Aug. 20, inclusive, Professor Newcomb

has derived the following approximate circular elements of the orbits. The probable errors assigned are only very rough estimates:—

The Outer Satellite.

Major semi-axis of apparent orbit, at distance [9·5930]	82″·5 ± 0″·5
Minor „ „	27″·7 ± 2″
Major semi-axis of orbit at distance unity	32″·3
Position angles of apsides of apparent orbit	70°, 250° (± 2°)
Passage through the west apsis ($p = 250°$)	Aug. 19, 16 h.6, W.M.T.
Period of revolution	30 h. 14 m. ± 2 m.
Hourly motion in areocentric longitude	11°·907
Inclination of true orbit to the ecliptic	25°·4 ± 2°
Longitude of ascending node	82°·8 ± 3°

Position of pole of orbit on celestial sphere:

long. 352°·8	R.A. 316·1
lat. +64·6	Dec. +53·8

These elements give for the mass of Mars, one 3,090,000th of sun's.

The Inner Satellite.

Major semi-axis of apparent orbit, dist. [9·5930]	33″·0 ± 1″
Period of revolution	7 h. 38·5 m. ± 0·5 m.
Hourly motion in areocentric longitude	47°·11.
Passage through the eastern apsis ($p = 70°$)	Aug. 20, 13 h. W.M.T.

It will be found, on comparing the position of the pole of orbit of the outer satellite with that of the pole of the Martian equator, as indicated in our paper on Mars in the July number, that the plane of motion of the outer satellite lies very near the plane of the Martian equator. Indeed, when we consider the nature of the observations by which the positions of both planes have been determined, we may fairly say that within the probable limits of error of observation these two planes are identical. From the elements given in the article on Mars, it will be seen that the R.A. of the pole of the Martian equator is assumed there to be 312° 4′, the north declination 50°·18′, according to which the two poles would be distant about 4° in R.A. and about 3½° in declination. The construction given in the above-named article will become strictly correct for the satellite orbit, in this or any future year (subject always to any change which may have to be made in the estimated elements, if, for N, 43°·9 be substituted, and for I (misprinted No. 1 in the article) 36°·2. As it is, the ellipse *e′e* represents with considerable correctness the nearer half of the orbit for the opposition of the present year.

The mass of Mars may be regarded as more correctly determined from the observations of the outer satellite during a few days, than from a century of observations and a mass of laborious computations on which Leverrier's masterly determination of the mass had been based. Since Leverrier determined the mass of Mars at one-2,968,300th of the sun's, it follows that the mass has been diminished by the difference between one-3,000,000th and

one-2,968,300th of the sun's mass, or approximately one-$\frac{121,700}{3,029,000}$th part of Leverrier's estimate, say one-25th of the 3,000,000th part of the sun's mass; or, since the earth's mass = one-350,000th part of the sun's, in round numbers, the reduction is equivalent to one-216th part of the earth's mass. We may say roughly that our estimate of Mars's mass must be diminished by one-200th part of the earth's mass, or by some 30 millions of millions of millions of tons.

Spectra of Comets b and c, 1877.—The spectrum of Winnecke's comet *b* 1877, examined with a Browning single prism spectroscope, by Copeland and Lohse of Lord Lindsay's observatory, was found to consist of three bright bands, closely resembling those of comet II., 1868, as figured by Dr. Huggins. The spectrum of comet *c* (Borelly's) was found also to consist of three bright bands, but not coinciding with those of the other comet. They seem to correspond with those seen by Huggins in the spectrum of Brorsen's comet of 1868, and comet I., 1871. The measures were all made with a spider line, or a steel cone, in either case feebly illuminated in an otherwise perfectly dark field. Lord Lindsay considers the steel cone the best, as it gives a broader line, and requires less illumination.

Two Flats on the Moon's Limb.—Dr. Ralph Copeland has recognized two remarkable "flats" on the moon's limb. The positive angles of their centres were found to be 264° 28′ and 272° 30′, their lengths being 1′ 39″·1 and 1′ 18″·2 respectively. They coincided sensibly with a spider line throughout their entire length. Assuming the lowest points to have been exactly on the moon's limb, these measures give the following results:—

	First Depression.	Second Depression.
Length in arc of moon's limb . .	5° 46′	4° 31′
Apparent depth	1″·24	0″·78
„ „ in feet, about . .	7,200	4,500
Selenocentric latitude . . .	−14° 25′	−6° 1′
„ longitude . . .	+87 18	+86·41

It seems highly probable that these indentations are identical with two of those seen by Cooper Key on Sept. 6, 1863. Dr. Copeland, after comparing together various observations, comes to the conclusions that,—

The first depression is most probably caused by the presence of the adjoining ring-plains, *Ansgarius* and *Behaim*, on the moon's limb;

And that the second depression is undoubtedly a vertical section of *Kästner*.

Collective Light and Distribution of the Fixed Stars.—Mr. J. J. Plummer has endeavoured to determine the total illuminating power of the stars as compared with acknowledged photometric standards. He finds that the total illuminating power of all the stars above the horizon at one time is not less than one-eightieth part of the illumination due to the full moon. In dealing with stars of lower magnitudes, he is led to the conclusion that either Argelander's *Durchmusterung* contains many stars (more than one-third of the entire number) which, though rated as 9·5 magnitude, are sensibly below it, or else it must be assumed that at the average distance for stars of this magnitude a denser stratum actually exists, succeeded possibly by regions less fruitful beyond. "Having been led to the latter conclusion in

opposition to preconceived ideas," he "considers that the enormously increased ratio with which the numbers of the telescopic stars are multiplied is deserving of increased interest and continued discussion." A very brief study of Mr. Proctor's chart projection of Argelander's *Durchmusterung* shows that Mr. Plummer's conclusion, though not correct for the star-sphere as a whole, corresponds with what is observed over the region of the Milky Way.

Two new Inequalities in the Moon's Longitude.—In June 1876, a correspondent of the "English Mechanic" pointed out, over the signature "W. G. P.," two theoretical inequalities in the moon's longitude which had not hitherto been noticed, suggesting that they may possibly explain some actual inequalities observed in the moon's motion. "Some years ago I found," he wrote, on June 30, p. 405, vol. xxiii. of the "English Mechanic," "that there were two inequalities, due partly to the direct and partly to the indirect action of Jupiter; the one of which agrees very exactly in period, and the other very fairly so" with those mentioned . . . They are:—

$$-1'' \sin \{(2-2i-c)t-2e+a\}$$

where i represents the mean motion of Jupiter, that of the moon being unity, and ·006306 being taken for that of i; also e and a are the mean longitude of Jupiter and of moon's perigee when $t=0$. "The period of the above is very nearly 27·434 days, which falls within the narrow limits 27·42 and 27·44, given by observation. It remains to be seen whether, besides this, 1″ represents pretty well the proper amount of the inequality at its maximum, and whether a maximum occurs at the proper time. With regard to the long inequality, it will be of the form—

$$p \sin \{(2-2i-2c)t-2e+2a\}$$

its period will be about $17\frac{1}{3}$ years. That of the observed is given at $16\frac{2}{3}$ years, with a probable error of half a year; and therefore with a possible error of eight months this would make it within the period of the calculated inequality." In later numbers these inequalities were discussed by "W. G. P." and by another skilful mathematician, W. C. Evans, who analysed their value, describing fully his method of procedure, and in particular explaining carefully, for a third correspondent, "N." (understood to have been Mr. Neison), certain difficulties under which "N." laboured. Nine months later these identical inequalities were submitted to the Astronomical Society by Mr. Neison, and so far claimed as his, that in a paper which appeared in the June number of the "Monthly Notices," Professor Newcomb, unaware of their prior discussion by "W. G. P." and Mr. Evans, speaks of them as "new inequalities in the moon's longitude pointed out by Mr. Neison." We would suggest to Mr. Neison's consideration that his procedure in this matter has been ill-considered. He has, we will assume, been able, directed as he was by the two mathematicians referred to, to recalculate these inequalities, with closer approximation to their true value. Whatever credit may be due to him on this account would gladly have been accorded; the credit of noticing the inequalities he should not have claimed, for it is not his.

Rotation of Saturn.—Professor Hall, from observations of a white spot just below the ring of Mars, finds the planet's rotation-period to be

10 h. 14 m. 23·8 s. ± 2·30 s.

Sir W. Herschel's estimate was

10 h. 16 m. 0·4 s;

the estimate commonly described as his latest, viz. 10 h. 29 m. 16·8 s., never having been given by him at all, but being in reality Laplace's theoretical estimate of the period of the ring's rotation.

Phenomena for the Quarter.—The most interesting phenomena during the next quarter will undoubtedly be the close approach of Mars and Saturn, at 4 A.M. on Nov. 4: Mars will be 11′ north of Saturn. Neptune will be in opposition to the sun on Oct. 29, at 11 A.M. Venus will reach her greatest easterly elongation on Dec. 11. Mercury reaches his greatest westerly elongation on Oct. 12, his greatest easterly elongation on Dec. 25.

CHEMISTRY.

Davyum.—Sergius Kern, of St. Petersburg, has sent to the "Comptes rendus," 1877, lxxxv. 72, a short notice on the occurrence of a new metal belonging to the platinum group, to which he has given the above name. The new element occurs in a specimen of native platinum, doubtless from a Russian locality; it is not stated, however, whence it was derived. The material which he had to work upon possessed the following composition:—

Platinum	80·03
Iridium	9·15
Rhodium	0·61
Osmium	1·35
Palladium	1·20
Iron	6·45
Ruthenium	0·28
Copper	1·02
Davyum	0·045
	100·135

600 grammes of the native alloy were treated by the method devised by Bunsen for the separation of the metals, and the mother-liquors remaining after the removal of rhodium and iridium were treated with an excess of ammonium chloride and nitrate; a dull red-coloured precipitate was formed by these reagents, and when calcined it left a grey mass resembling spongy platinum. When heated in the flame of the oxyhydrogen blowpipe it fused together, forming a little bead, having the colour of silver and weighing 0·27 gramme. This is the new metal, which is stated to be hard at ordinary temperatures and malleable at a red heat, and to possess the specific gravity of 9·385 at 25° C. Davyum is easily acted upon by aqua regia, but resists in a marked degree the action of boiling sulphuric acid. Potash throws

down a yellow precipitate, and sulphuretted hydrogen causes the separation from an acid solution of a brown sulphide, which is black when dry. Potassium sulphocyanide strikes a red colour in dilute solutions of the chloride: a feature which, as Kern points out, the new metal possesses in common with iron. The author does not refer to the fact that solutions of ruthenium exhibit the same reaction, so that it can hardly be referred to as a characteristic property of his new element. He believes, on what grounds we are not told, that davyum is the hypothetical element which in Mendelejeff's classification is placed between molybdenum and ruthenium, in which case its equivalent would be 100. The results of his investigation of the chemical and physical properties of the new metal will be published in a few months, when it is to be hoped more characteristic reactions will have been studied.

The Occurrence of Hyposulphites in Human Urine.—Schmiedeberg and Meissner found hyposulphurous acid to be an almost constant constituent of the urine of the cat, and to be frequently present in that of the dog; Strümpell ("Zeitschrift für Anal. Chemie," 1877, xvi. 134) has now detected its presence in that of a patient suffering from typhus fever. He was led to search for this acid through his attention having been directed to an unusual reaction which the liquid exhibited with silver-solution, during a volumetric determination of the chlorine: a reaction which those who perform analyses of this kind would do well to study. In the case which he examined he found that 1·5 gramme of sulphur passed from the body every twenty-four hours in other forms than that of sulphate. Calculated as hyposulphite, it would amount to a daily yield of 2·25 grammes of that salt.

Preparation of Hydriodic Acid.—While writing that portion of his "Kurzes Lehrbuch der anorganischen Chemie" which treats of the preparation of this acid, Kolbe's attention was directed to the method given in the text-books of Fittig, Von Richter, and Roscoe and Schorlemmer, where the quantities of iodine and water employed appear to be far in excess of those required to enter into reaction with the prescribed amount of phosphorus. It is the custom in the Leipzig Laboratory to add, by slow degrees, to ten parts of iodine, placed in an atmosphere of carbonic acid, one part of common phosphorus; and to pour on the mixture of di-iodide and tri-iodide, after it has become cold, four parts of water. The application of a gentle heat causes the disengagement of abundance of hydriodic acid, which is not contaminated with free iodine. Kolbe tried the proportions recommended in the three text-books, and first suggested by Vigier, where fifteen parts of water are to be poured on one part of amorphous phosphorus, and twenty parts of iodine are to be gradually added; and he finds this method useless. When heat is applied, much water and little acid pass off, and that little is strongly coloured with iodine (*Journ. Prakt. Chem.*, 1877, xv. 172).

A New Carbo-hydrate in Milk.—Ritthausen has found in milk a carbohydrate which is not milk-sugar ("Journ. Prakt. Chem.," 1877, xv. 348). It occurs in small quantities only, and is easily soluble in water. Its solution forms with a small quantity of the copper reagent the well-known blue liquid; when boiled for a long time a little cuprous oxide is deposited. If the liquid be previously warmed with a little sulphuric acid, the application of a gentle heat is sufficient to cause a copious reduction. Alcohol throws

down a flocculent precipitate from an aqueous solution of the substance, when evaporated to dryness, either by the application of heat, or at ordinary temperatures over sulphuric acid, there is left a gum-like viscous residue, in which the granular non-crystalline substance can be recognized. This reaction shows that the body under consideration is not milk-sugar.

A Wine of Great Age.—Berthelot describes ("Comptes rendus," 1877, lxxxiv. 1060) a wine, probably fifteen or sixteen centuries old, which was found in a sealed vessel of glass at Aliscamps (*Campi Elysei*), near Arles, and has been preserved in the Musée Borely at Marseilles. The glass vessel, which is figured in his paper, possesses a very curious form, and displays the etched, corroded, and iridescent appearance of glass of extreme age. The yellow liquid, which nearly filled the vessel, possessed a vinous odour, was distinctly aromatic, and recalled the characters of a wine which had been in contact with fatty bodies; the flavour was hot and strong, due to the presence of alcohol, acids, and a trace of aromatic substance. The composition per litre was found to be—

Alcohol	45·0 c. c.
Fixed acids, estimated as free tartaric acid .	3·6 grammes.
Bitartrate of potash	0·6 „
Acetic acid	1·2 „

as well as tartrate of lime in quantity which could be recognized, and traces of acetic ether. A trace of sugar, or rather of a substance which could reduce cupro-potassic tartrate, was recognized.

Solubility of Sulphur in Acetic Acid.—Liebermann ("Wien. Anz." 43, 1877) finds that sulphur is soluble to no inconsiderable degree in warm concentrated acetic acid, and that a trace is taken up even by the dilute acid. If the concentrated solution be diluted with water, much of the sulphur separates as milk of sulphur; if it be evaporated with the Sprengel pump, fine long prisms of sulphur separate; when cooled, moreover, the liquid deposits sulphur in a crystalline form. All modifications of the element appear to be taken up by acetic acid. The author refers to analytical methods where these changes occur, and are apt to mislead the operator.

A Red Colouring Matter accompanying Chlorophyll.—Harsten obtained two colouring matters from chlorophyll: a carmine (purpurophyll) and a yellow (chrysophyll). Bougarel has discovered ("Bull. Soc. Chim.," Paris, xxvii. 442) another colouring substance, which occurs associated with chlorophyll in the fresh and young leaves of many plants. Leaves of the peach were treated with ether until all the chlorophyll had been removed, and then they were directly digested with alcohol. After the lapse of two days the sides of the vessel and the surface of the leaves were covered with small brilliant crystalline plates, which exhibit the green hue of fuchsine by reflected light; by transmitted light they show a fine red colour; certain of them were observed under the microscope to have the crystalline form of uric acid. They are insoluble in water and nearly insoluble in potash, acetic acid, hydrochloric acid, alcohol, and ether; they are, however, readily taken up by chloroform and benzol, to which they impart a yellow tint, and in carbon disulphide, which they colour red.

Emodin.—Liebermann and Waldstein have isolated a crystallized product

from the bark of the buckthorn, (*Rhamnus frangula*) by treating it with dilute soda solution ("Ber. deut. Chem. Gesell.," ix. 1775). An analysis of the purified substance gave numbers corresponding with the formula $C_{15}H_{10}O_5$, which Liebermann has shown to be that of emodin, first obtained by De La Rue and Müller from rhubarb root. The bark of the buckthorn contains about 0·2 per cent. of this substance. When distilled with zinc powder it yields a mixture of anthracene and methyl-anthracene. Whether frangulinic acid also exists in this bark has not yet been determined.

The Phosphorescence of Organic Compounds.—Radziszewski finds that formic aldehyde and grape sugar, when mixed with an alcoholic solution of potash, and warmed in presence of air, become phosphorescent ("Beiblätter Ann. Physik und Chemie," 1877, i. 242). As Duchemin has noticed that *Noctiluca miliaris* can produce a burning sensation on the skin, it appears possible that it may secrete formic aldehyde, which changes in presence of oxygen to formic acid. The phosphorescence noticed in the case of grape sugar is a further indication of the probability of its being of the nature of an aldehyde. Neurine, which does not form aldehyde under similar circumstances, is not phosphorescent.

Action of Carbonic Acid.—Mohr has called attention ("Annalen der Chemie," clxxxv. 286) to a number of apparently anomalous decompositions produced by carbonic acid, in which stronger acids, such as phosphoric acid, acetic acid, and chromic acid, are expelled from their compounds by means of carbonic acid.

GEOLOGY AND PALÆONTOLOGY.

A Gigantic American Dinosaur.—The Cretaceous deposits of Colorado have lately yielded portions of a Dinosaur, which would appear to have exceeded in magnitude any terrestrial animal of which we have any knowledge. Professor Marsh descibes it ("Silliman's Journal," July, 1877,) under the name of *Titanosaurus montanus.* The most characteristic parts preserved are the last two sacral vertebræ, with their transverse processes, and portions of the posterior limbs. The vertebræ are remarkable as having such deep concavities as materially to lessen their bulk, in which they somewhat agree with those of *Eucamerotus* or *Streptospondylus,* described by Mr. Hulke; but in some of the vertebræ, at any rate, there are cavities in each side, which communicate with the surface of the vertebræ through a foramen opening below the base of the neural arch. These cavities the author believes to be pneumatic. From the measurements of the parts preserved Professor Marsh estimates the length of the entire animal at from 50 to 60 feet, and he believes it to have been herbivorous, and a distant ally of the small *Hadrosaurus agilis,* the only Dinosaur hitherto found in the Cretaceous of Kansas.

A Carboniferous Hexactinellid Sponge.—Mr. Carter has called attention ("Ann. Mag. Nat. Hist.," Sept. 1877) to the occurrence in the lower Carboniferous Limestone of Dalry, Ayrshire, of fossilized portions of a sarco-hexactinellid sponge, allied to *Hyalonema.* The fossils consist of spicules and fragments of spicules, among which are "the hexactinellid spicules of the body *in situ,* the long linear anchoring spicules, in at least

three specimens of the 'lash' or 'glass-cord' *in situ*, and fragments of the fluked ends of the anchoring spicules of the same lash, probably, but *separate*," thus furnishing all the skeleton-spicules that a hyalonematous sponge could present. The flesh-spicules, from their minuteness, could hardly have been preserved. The author is of opinion that probably the fossils described under the name of *Acanthaspongia*, McCoy, and *Protospongia*, Salter, are also remains of sponges of the same group as the above.

A new British Coral.—Professor Nicholson and Mr. R. Etheridge, Jun., have described ("Ann. Mag. Nat. Hist.," Sept. 1877) a new species of tabulate coral, which they refer to Professor Dana's genus *Tetradium*, the distinctive characters and affinities of which they discuss at considerable length. They come to the conclusion that *Tetradium* is most nearly related to *Halysites*, but with some affinities to *Chætetes*, thus forming a sort of connecting link between the two families of tabulate corals, the *Halysitidæ* and *Chætetidæ*. They notice two species of the genus:—the *Tetradium minus* of Safford, from the Silurians of the United States and Canada (Cincinnati and Hudson River Groups), and *T. Peachii*, a new species found in pebbles of Silurian limestone, contained in the Old Red conglomerates of Habbies How, in the Pentland Hills, near Edinburgh.

A Silurian Annelid.—Worm-tracks have been long known as almost the only indications of the existence of animals in certain very ancient rocks, but in these nothing more than the tracks have been detected, whilst in some fossiliferous deposits, the only traces of annelids have been of a similar nature. Mr. G. B. Grinnell now describes ("Silliman's Journal," Sept. 1877), some remains, apparently of Annelids, obtained by Mr. A. G. Wetherby, from Lower Silurian rocks near Cincinnati. He regards the bodies fossilized as probably the jaws of a worm allied to the existing genus *Nereis*. He describes the largest and most perfect jaw, which is rather more than a fifth of an inch long, as of a dark brown colour, hollow from the base throughout the greater part of its length, and having numerous denticulations (eight are preserved in the specimen) along its side. The anterior tooth is the largest and slightly twisted outwards; the teeth towards the base are deficient. He also notices another form, which bears eighteen teeth, of which the anterior is long and stout, the five following very small, and the remainder sharp and strong. This fossil is only half the length of the other, and the author seems inclined to identify it with one of the setæ of a nereiform worm.

A new Triassic Lizard.—Professor Oscar Fraas describes and figures ("Württemb. naturw. Jahreshefte, xxxiii. Heft. 3, 1877") a most extraordinary group of fossil reptiles, obtained from a sandstone quarry in the Middle Keuper, near Heslach. No fewer than twenty-four individuals of the same species were found in a slab of sandstone having a surface of about two square metres; the animals were beautifully preserved, and in some cases their attitudes are almost life-like, all the hard parts, including the bony dermal scutes, being there in their natural position. The effect of the group is increased by the fact that all these bony parts have become converted into vivianite, the blue tint of which contrasts wonderfully with the greyish colour of the stone. Professor Fraas describes this animal in great detail, and refers especially to certain bird-like characters presented by the

skull, which have led him to give the name of *Aetosaurus* (or eagle-lizard) to the new genus which he establishes for its reception. The teeth, which are inserted in distinct sockets, have a cylindrical root and a compressed, somewhat lance-shaped crown; the central cavity is very wide in the cylindrical root, but gradually narrows towards the point of the crown, during its passage through which it gives off numerous branched canals towards the periphery of the tooth. Professor Fraas regards this tooth as more like that of *Ptreodactylus* or *Rhamphorhynchus*, than of a lizard or crocodile. The whole body is covered with bony plates, as is also the long tapering tail. The systematic position of this reptile is rather difficult to determine. The author says that the bones of the skull and those of the extremities point sometimes to one, sometimes to another type of reptiles, whilst at the same time the bird-type peeps forth in the four perforations of the cranium, the perforation of the lower jaw, and the sabre-shaped shoulder blade. He is of opinion that *Aetosaurus* is probably one of those Ornithoscelida with lacertilian characters, the occurrence of which has been anticipated.

Archæopteryx.—According to a statement in the "Zoologische Garten," a second specimen of *Archæopteryx lithographica* has lately been obtained from the quarries at Pappenheim, near Solenhofen, where the only other known example of this singular bird was discovered some twenty years ago. The new specimen is said to be much more perfect than the former one, and especially to have the head entire.

Food of a Siberian Rhinoceros.—Dr. J. Schmalhausen has made a microscopical investigation of the fragments of food picked out of the cavities of the teeth of a Siberian *Rhinoceros antiquitatis* (=*tichorhinus*), preserved in the Museum at Irkutsk. He identified portions of grasses, and the small twigs of some woody plants, such as *Pinus picea*, *Abies*, *Larix*, *Betula*, *Ephedra* and *Salix*, and although he is not quite certain about the species, most of them closely resemble well-known plants still growing in high northern latitudes. This furnishes fresh support to the opinion, originally expressed by Brandt, that the rhinoceroses and other great pachyderms of Siberia actually lived at or close to the spots where their frozen bodies are now to be found.

The Quaternary Fauna of Gibraltar.—After long investigation, Professor Busk has communicated to the Zoological Society the results at which he has arrived from the examination of a large series of mammalia, from the ossiferous breccia of the caves of Gibraltar. These remains belong to a far more ancient fauna than that described by Professor Busk in a former paper; he refers them "in all probability to the early Pleistocene, if not Pliocene, epoch."

The following animals are recorded. A species of bear (*Ursus fossilis* or *arctos*), the spotted hyæna (*H. crocuta*), a leopard (*Felis pardus*), a lynx (*F. pardina*), a cat (*F. caligata*), the horse (*Equus cabullus*), a rhinoceros (*R. hemitœchus*), two species of deer (one resembling the fallow deer, *Cervus dama*, the other probably *Cervus elaphus*), an ibex (*Capra hispanica*), an ox (*Bos primigenius?*), a wild pig (*Sus scrofa*), hares and rabbits, and a molar of *Elephas antiquus*. It is remarkable that no remains of the Gibraltar monkey (*Macacus inuus*) occurred in these deposits.

From these results Professor Busk draws the following conclusions. The rock of Gibraltar, after undergoing its last changes, but while still united to Africa, was covered with trees, and harboured numerous large mammals. Some of these species, such as the elephant and rhinoceros, are now extinct; and others, such as the spotted hyæna, now exist only in the southern part of Africa. The leopard and *Felis caligata* are no longer found in Europe, but the lynx and Spanish ibex still inhabit the mountains of Spain. The entire fauna exhibits purely African affinities, and the author infers from the occurrence of *Elephas antiquus, Rhinoceros hemitœchus,* the hyæna and the cats at this southern point of Europe, unmixed with northern forms, that those species probably made their way northwards through the isthmus formerly connecting Europe and Africa at this point.

METEOROLOGY.

The Heat Evolved by Meteorites in Traversing the Atmosphere.—M. Govi, in a note presented to the French Academy of Sciences ("Comptes rendus," Aug. 20), discusses this question. M. Schiaparelli has demonstrated that, in order to calculate the loss of velocity of a body penetrating the atmosphere, it is not necessary to know the law according to which the density of the air varies in the different strata of the atmosphere traversed, but only the barometric pressure at the two extremities of the course, or (what comes to the same) the weight of air displaced by the body the initial velocity of which is known. M. Schiaparelli has also ascertained that the velocity of meteorites varies between 16,000 and 72,000 metres per second. Taking 50,000 metres per second as an average velocity, M. Govi calculates that a meteorite penetrating vertically into the atmosphere with this initial velocity would have a velocity of only 28,968 metres per second on reaching the point where the barometric pressure is one millim., 5,916 metres at ten millims., 506 metres at 100 millims., and five metres per second at the level of the sea. Taking these figures as indicating the lowest effect producible on a meteorite by the resistance of the air, M. Govi calculates that the number of calories corresponding to the loss of *vis viva* of a meteorite of 14·66 kilogr. reaching the stratum of air where the pressure is scarcely one millim., would be 2,921,317, which would more than suffice to explain all the phenomena of light and heat, and all the mechanical effects produced by the penetration of a meteorite into the highest strata of our atmosphere. Even at an elevation where the barometric pressure is only 0·001 millim., the meteorite in question might already have developed 6,413 calories, and have become visible. This, according to M. Govi, explains the enormous elevation of some meteorites the distance of which from the earth has been measured.

Sun-spots and Storms.—Mr. Henry Jeula, of Lloyd's, has lately written to the "Times" indicating that there appears to be some connection between the prevalence of sun-spots and the number of wrecks posted annually in Lloyd's "Loss Book," and that this may constitute a further link in the evidence connecting sun-spots with the phenomena of weather. He derives his data from two complete cycles of eleven years each, extending from

1855 to 1876. He divides each series of eleven years into three periods, and finds that there are two minimum periods of four years at the beginning and end of each cycle, having between them a minimum period of three years.

MINERALOGY.

Uranocircite.—Weisbach has given this name ("Jahrbuch für Mineralogie," 1877, p. 406), to the interesting new member of the group of "uranium-micas" which occurs in quartz veins in the granite of Bergen, near Falkenstein, in Saxon Voigtland. It is remarkable for containing baryta in place of lime, as the following analytical numbers show:—

Uranium oxide	55·86
Baryta	14·57
Phosphoric acid	15·06
Water	13·99
	100·48

The percentage of baryta (14·57) differs but slightly from that required by theory (15·60). Uranocircite forms the fifth member of this interesting group. It is curious to find that half a century ago Berzelius detected the presence of baryta as well as lime in specimens of the "uranium-mica" of Autun, while later mineralogists have found lime only.

New Localities of Minerals in Scotland.—Professor Heddle, of St. Andrew's, has met with quite a number of minerals in a block of granite, which was being used for building purposes near Tongue, in Sutherlandshire. He recognized the presence of amazon stone (a variety of orthoclase felspar, of a bright green colour), in isolated and twinned crystals, cleavelandite, lepidomelane, pinite, fluorite, sphene, zircon, magnetite, ilmenite, allanite, smoky quartz, and a mineral which has been shown to be thorite passing into orangite. On a part of the surface of the block, about three square feet in area, twelve large crystals of amazon stone were seen, eight of these being unbroken and perfect; one crystal of this mineral attained the length of 15½ inches, and measured 10 and 8 inches in the other directions. The block appears to have come from Ben Laoghal, a few miles inland to the north-west.

Bunsenine.—This new mineral, a crystallised telluride of gold which occurs at Nagyág, and to which Krenner gave the name of *Bunsenite*, is now to bear the altered name of *Bunsenine*, as the former term had already been applied to a native oxide of nickel met with at Johanngeorgenstadt. Bunsenine occurs in small grey rhombic crystals on quartz. Its chemical constitution is not yet made known, but the analytical results obtained by Wartha will shortly be published.—*Annalen der Physik und Chemie*, 1877, i. 636.

Homilite.—A new rhombic or monoclinic mineral, to which this name has been given, has been found by Paijkull at Stockhoe, near Brevig, associated with erdmannite and melinophane. It has a black, or brownish-black

colour, a waxy or vitreous lustre, and when in thin flakes is feebly translucent. The hardness is 5·5, the specific gravity 3·28, and the analytical results point to the formula $3(CaO, FeO), 2SiO_2, BaO_3$, as representing its composition.—*Verh. Geolog. Vereins Stockholms*, iii. 229.

Sphaerocobaltite.—Weisbach has given this name to a new member of the calcite group occurring at Riechelsdorf associated with the beautiful mineral roselite. It is found in spheroidal masses, black on the exterior, but exhibiting on the interior the fine red colour of erythrite (cobalt arsenate hydrate). It possesses the specific gravity of 4·02 and the following composition:—

Cobalt oxide	64·25
Carbonic acid	35·75
	100·00

and is therefore a cobalt carbonate.—*Jahrbuch für Mineralogie*, 1877, 409.

PHYSICS.

The Telephone.—During the recent session of the British Association at Plymouth, the lion's share of attention was unquestionably given to the telephone. Wherever the instrument was to be exhibited—whether in the Physical or in the Mechanical sections, or at Mr. Preece's popular evening lecture—there were always crowded audiences eager to learn something about so novel an apparatus. At the *soirées*, too, the telephone stood above everything else as the centre of attraction; and knots of people were crowded round the instrument, anxious to converse with friends in distant apartments. The interest in this subject culminated in the arrival of Professor Graham Bell, the inventor of the "talking telegraph."

Mr. Bell is a native of Edinburgh, who emigrated to the New World, and settled first in Montreal, and afterwards at Boston. Following his father's profession as an elocutionist and teacher of the deaf and dumb, he had been led to study with great care the manner in which air is thrown into vibration by the vocal cords, and the way in which these vibrations are received by the organ of hearing. By experiments on a dead human ear, he conceived the possibility of throwing a membranous disc, or artificial drum, into a state of vibration by the voice, and of transmitting these vibrations along an electric wire. His early experiments, made five years ago, were the very reverse of successful; but by successive modifications he so improved the instrument that he was able to exhibit at the Centennial Exhibition last year a telephone worthy of Sir William Thomson's notice. It was to this instrument that the Glasgow professor referred when addressing the Physical section of the British Association at last year's meeting.

Since the close of the Philadelphia Exhibition, the development of the telephone has occupied Professor Bell's constant attention. Every part of the apparatus has been modified again and again, and even the instrument which he exhibited at Plymouth will probably be superseded in due course by improved forms. But in its present state—immature as the inventor

believes it to be—it is yet capable of rendering distinctly the words, or even the cough or sneeze, of a person thirty or forty miles distant. And the marvel of all this is greatly enhanced when one sees the extreme simplicity of the apparatus by which such extraordinary results are brought about. A small mahogany cylinder, which can be easily carried in the pocket, and is strongly suggestive of a stethoscope, contains all the mechanism; nothing indeed is visible outside except a mouthpiece at one end, and a couple of binding-screws at the other. Moreover, this modest little bit of apparatus serves equally for the transmitter and for the receiver of the sounds. You first speak through the mouthpiece, and then transfer it to the ear and listen for the reply. Even the interior of the wooden cylinder is simple in the extreme. Near to the mouthpiece there is a small disc of thin sheet-iron, which is thrown into vibration by the voice. These vibrations are executed in front of a soft-iron core attached to one pole of a permanent bar-magnet, and surrounded by a small coil of No. 38 silk-covered copper wire, one end of which is connected with the line-wire, while the other end communicates with the earth. The permanent magnet induces a magnetic field all round it, and attracts the iron diaphragm. When this disc vibrates, the condition of the magnetic field is affected, and a current is consequently induced in the coil; the strength of the current depending upon the amplitude and form of the vibrations. Each induced current traverses the line-wire, and passing through the coil of the receiving instrument, alters the magnetism of its core; thus increasing or diminishing its attractive effect on the iron disc, which is therefore thrown into a state of vibration. The vibrations of the receiving diaphragm are executed in perfect unison with those at the transmitting station, and consequently every sound uttered at one end, even to the nicest modulation of the voice, is reproduced at the other end.

Many of those who experimented with the telephone at Plymouth, and failed to get very audible replies, may have concluded that it is far from being a trustworthy instrument. But it should be borne in mind that Bell's instrument is so extremely sensitive, that when in connection with a telegraphic line, the currents along the neighbouring wires induce currents in the coils of the telephone, and the oscillating disc then produces a hum which almost overpowers the voice. In the United States, however, the apparatus is in practical use, instruments on Bell's principle being worked in New York, in Boston, and in Providence. At Plymouth verbal messages were sent from one part of the town to another; and in some of the deep Cornish mines conversation has since been carried on between the bottom of the shaft and the surface. Mr. Edison, of New York, has effected certain improvements in Professor Bell's apparatus; and Mr. Preece tells us that, with this improved form of telephone, words have been distinctly heard through a resistance equivalent to a distance of a thousand miles of wire. In the face of these results, no one will dare to say that oral telegraphy is not an accomplished fact.

While Bell's telephone is at present unique as an apparatus for the transmission of articulate speech, it need hardly be said that there are several other forms of telephone capable of transmitting musical notes, though not distinct words. Such, for example, is Mr. C. F. Varley's instrument, which

has recently been working in London, and has conveyed musical sounds between the Canterbury Hall and the Queen's Theatre. Mr. Varley's invention dates back to 1870, when he patented a method, or rather several methods, whereby he could send rapid electrical undulations along an ordinary telegraph line, and reproduce these undulations as audible sounds at the other end. A tuning-fork, with one leg longer than the other, and having its shank connected with a battery, is caused to vibrate between a pair of electro-magnets. The vibrations generate momentary currents in the two primaries of an induction-coil, which are also connected with the battery. These currents in the primaries induce a succession of alternate currents or electric undulations in the secondary coil; and by means of a signalling-key these undulations are caused to alternately charge and discharge a condenser attached to the line. Hence a series of electric waves are caused to traverse the line, in unison with the vibrations of the fork. Or instead of the fork, a vibrating reed may be employed. The undulations which are thus transmitted are received at the opposite end of the line by an apparatus called a *cymaphen*, of which several different forms are described by the inventor. If the currents pass round a helix containing an iron rod, the latter is caused to vibrate; or if the coil contain a magnetized harmonium tongue, this in like manner will vibrate, and in either case musical sounds are produced. Again, if the currents circulate through a wire helix which encloses a hard-drawn iron or steel wire, stretched over bridges on a sounding board, the wire is magnetized whenever a current passes through the coil, and is alternately attracted and repelled by a pair of electro-magnets, one on each side of the wire; the vibrating wire then emits sounds similar to those of the oscillating tuning-fork at the transmitting station. Moreover, it is possible to obtain a musical note by the rapid charge and discharge of a condenser at the receiving end. In any of these ways audible sounds may be obtained, corresponding with the vibrations of a tuning-fork or of a reed at the distant end of a telegraphic line.

During the years 1874, 1875, and 1876, patents for various forms of telephone were obtained in this country by Mr. Elisha Gray, of Chicago. Without entering into the details of the mechanism by which the patentee sends a succession of electric impulses along a telegraphic line—as by the vibration of a series of tuning-forks of different pitch—it is sufficient to call attention to one extraordinary form of his receiving apparatus. This curious instrument is sometimes called the "physiological receiver," for reasons which will be obvious on explaining its action. It consists of a small cylindrical box of thin wood, with one face of sheet zinc slightly bulged out, and having an air-hole in the centre. The box is mounted on a horizontal axle, by which it can be rapidly rotated in a vertical plane. The electric current from the line passes, in most forms of this telephone, to the primary wire of an induction coil, and thence to the earth. One end of the secondary wire of this coil is connected with the axle of the receiver, and thence with the zinc face, while the other end of the wire is held in the hands of the operator. With one finger of that hand he presses upon the zinc disc, while he rotates the apparatus with the other hand. On the passage of an induced current, which is thus forced to pass through the body of the operator, who is in the secondary circuit, a distinct musical note is

emitted by the resonant box, corresponding with that of the vibrating fork at the transmitting station. A mere accident suggested in the first instance this remarkable form of apparatus, and the theory of its action still remains extremely obscure.

Whilst English and American electricians have thus been busying themselves with the telephone, the subject has by no means been neglected on the Continent. Thus M. Paul de la Cour, of the Meteorological Institute at Copenhagen, has constructed several forms of telephone, which have been successfully worked on some of the Danish lines. A tuning-fork is placed in a horizontal position, with its shank connected by means of a signalling key with the transmitting battery. On vibration of the fork, one leg comes in contact with a metallic spring, whereby connection is momentarily established with the line-wire. By rapidly making and breaking contact, a series of intermittent currents will be transmitted to the receiving instrument. This consists of a soft iron tuning-fork with each leg surrounded by a helix of silk-covered copper wire. On the passage of a current through the bobbins, the enclosed legs are magnetized. But in front of the legs are two electro-magnets, round which the current is also caused to circulate; and as it is so arranged that the legs acquire opposite polarity, attraction ensues, and the legs are consequently pulled out each time the current passes. The rapid movements thus produced by intermittent currents throw the surrounding air into vibration, and produce a note of the same pitch as that of the oscillating fork at the transmitting end of the line. If several instruments are employed, a number of distinct signals may be simultaneously transmitted along a single wire; for the intermittent current acts only on the particular fork which is in unison with that at the other end, and which is therefore competent to take up the vibrations.

As the telephone promises to become of great practical value, it is interesting to look back upon the earliest form of the instrument, and mark its relation to the later forms of apparatus. There can be no doubt that the oldest telephone is that which was invented in 1861 by Professor Reiss, of Friedrichsdorf, near Homburg. This is in fact the parent of all the recent telephonic brood. In using Reiss's instrument the operator sings through a mouthpiece into a wooden box, and thus throws into vibration a thin membrane, which is stretched across a large aperture in one side of the box. The membrane carries a small metallic disc connected with a battery, and every time this disc oscillates it comes in contact with a little platinum point attached to the wire of the telegraphic line. Contact is thus frequently made and broken, and a rapid succession of currents is consequently transmitted. The currents circulate around the helix of an electro-magnet at the receiving station, where they magnetize and demagnetize the enclosed bar more or less rapidly, according to the character of the note. But this rapid magnetization and demagnetization give rise to molecular changes in the bar, which produce a musical note: it is in fact the "galvanic music" which Page discovered in America forty years ago, but which remained unutilized until Professor Reiss suggested this application.

Although Reiss is fairly entitled to be called the inventor of the telephone, it is worth noting, as an historical curiosity, that the invention had been anticipated several years earlier. Dr. Paget Higgs has lately written to

"Nature," calling attention to a curious passage in the "Exposé des Applications de l'Electricité," by M. Le Comte du Moncel. In this work, dated 1857, the author refers to a friend's prediction of the possibility of transmitting speech by electricity, but regards it of course as simply a wild dream, scarcely worth mentioning. "Imagine," says this far-seeing friend, "that one speaks near a mobile plate, flexible enough not to lose any of the vibrations produced by the voice; that this plate establishes and interrupts successively the communication with a battery. You would be able to have at a distance another plate which would execute at the same time the same vibrations." Here then is a clear foreshadowing of the principle not merely of the tone telegraph, but of its highest development—the talking-telegraph.

After all, there is nothing new under the sun—even in telephones.

A New Photometric Unit.—In comparing one source of illumination with another, it is of first importance to possess some standard unit by which the comparison may be made with scientific accuracy. To test the illuminating power of coal-gas, use is generally made of a photometric standard, which has been defined by Act of Parliament as a sperm-candle of six to the pound, consuming 120 grains of sperm per hour. For example: "14-candle gas" is gas which gives a light equal to fourteen of these standard candles. But it is impossible to get candles uniform in composition and in structure of the wick, while the amount of light which a given candle emits varies with the temperature and pressure of the surrounding atmosphere. Hence a good deal of uncertainty hangs over all photometric determinations. Mr. Vernon Harcourt, one of the Metropolitan gas-referees, has recently devised a new unit of light for photometric purposes, which he believes will satisfy all the conditions required for a trustworthy standard flame. The combustible used ought to be of definite chemical composition, burning under simple and definable conditions, and affected as little as possible by atmospheric changes. Mr. Harcourt's standard is a mixture of air with that portion of American petroleum which distils at a temperature not above 50° C. This liquid consists almost exclusively of pentane, the fifth member of the paraffin series. To form the standard mixture 600 volumes of air are mixed with one volume of the liquid pentane; the liquid rapidly volatilizes, and an uniform mixture of air and vapour is soon obtained. This combustible mixture is to be burnt from a $\frac{1}{4}$-inch orifice, at the rate of half a cubic foot per hour, under a temperature of 60° F. and a pressure of 30 inches of mercury. No change will be needed in the nomenclature of photometry, by the introduction of Mr. Harcourt's standard-flame; for the new unit is equal to the old ordinary sperm-candle unit, but much more constant and trustworthy.—*Chemical News*, Sept. 7, 1877.

Rain-bands in the Solar Spectrum.—By means of a miniature spectroscope, which can be carried in the waistcoat pocket, it seems possible to make rapid observations on the proportion of moisture in the atmosphere, and consequently to form a fair opinion as to the chance of coming rain. Professor Piazzi Smyth has described some interesting results of this kind, obtained during a recent journey from Edinburgh to Lisbon. The spectrum of daylight is examined through a spectroscope having a very fine and clean slit; and as it is necessary to look through a great thickness of atmospheric air, the instrument is directed to the sky nearest to the horizon. If the

atmosphere is highly charged with moisture, the aqueous vapour gives rise to a band of dark lines near the red end of the spectrum. A group of lines is very conspicuous, and may be termed the *rain-band.* This rain-band increases in strength in passing from colder to warmer climates. The information thus obtained spectroscopically is, in some sort, equivalent to that derived from the readings of the wet-and-dry bulb thermometers, and the subsequent calculations necessary to determine the hygrometric state of the atmosphere.—*Astronom. Reg.*, Sept. 1877.

Chromatic Aberration of the Eye, and Perception of Distance—No one now-a-days supposes that the human eye is a perfect optical instrument, at least in the sense in which an optician speaks of an instrument as perfect. The eye possesses, for example, decided chromatic aberration. Rays of light of dissimilar colour are not brought at once to an exact focus upon the retina, but each colour has its own focal distance. Let a red object and a blue object, of equal size, stand side by side, and it will be found that the images of these two cannot be in focus at the same time; therefore the two objects appear to be unequally distant, or of unequal magnitude. Hence estimates of distance founded on apparent magnitude are liable to be rendered fallacious by the colour of distant objects. And, on the other hand, estimates of distance founded on colour are liable to be confused by apparent magnitude. So far as our ideas of distance are dependent on the accurate focussing of rays upon the retina, it is evident that a source of error must be thus imported into the data of our perceptions. The subject has lately been very ingeniously handled by Mr. S. P. Thompson, of the University College of Bristol. He enumerates the various data for forming an estimate of distance which are dependent upon the eye, and not upon the limbs. After discussing the respective values of these data under various circumstances, he inquires how far they may be dependent upon the colour of an object, or upon the formation of an exact focus on the retina. Mr. Thompson concludes that the muscular sensation of adjustment of the eye to the focus of its lenses affords a possible means of estimating distances. When binocular methods, and those dependent on association of visible form and magnitude, fail, then the eye falls back upon colour as a means of effecting this. In fact, colour may in some cases outweigh the evidence of binocular vision. The chromatic aberration of the eye accounts for the well-known opinion of artists that blue is a retreating colour, and red an advancing colour. Aerial perspective is indeed a true expression of a physical fact in the perception of distance. Mr. Thompson's paper is interesting as offering a scientific explanation of certain empirical rules of artistic practice, relative to the expression of distance in painting.—*Philosophical Magazine*, July, 1877.

Diamagnetism of Hydrogenium.—When the late Professor Graham succeeded in charging palladium with hydrogen, or in "occluding" the gas so as to form what he regarded as an alloy of palladium and hydrogenium, he was puzzled with the anomalous magnetic behaviour of the new alloy. It is well known that palladium, like iron, is a magnetic metal; but it is believed that hydrogen is diamagnetic—that is to say, it is repelled instead of being attracted by the poles of a magnet. Hence it might be assumed, *à priori*, that the diamagnetic hydrogen would tend to neutralize the magnetism of the palladium, and that the alloy would consequently be less

magnetic than the palladium in a free state. As a matter of fact, however, this was found not to be the case. In short, the palladium charged with hydrogen was, according to Graham, *more* magnetic than in its ordinary state. Palladium is but feebly attracted by a magnet, but the hydrogenized palladium is much more powerfully attracted. The cause of the anomaly has been a fruitful source of dispute, and has led M. Blondlot to set to work and repeat Graham's experiments afresh, in order to see whether the discrepancy really exists. His results are in all cases diametrically opposed to those of Graham. In fact, he finds that the palladium, when charged with hydrogen, is *much less* attracted than when in a free state; thus showing that hydrogenium, like gaseous hydrogen, is diamagnetic. It is believed that Graham's curious results were due to impurities in the materials with which he experimented.—*Comptes rendus*, lxxxv. p. 68, July, 1877.

ZOOLOGY.

A One-armed Hydroid.—Under the name of *Monobrachium parasitum*, M. Mereschkowsky describes ("Ann. and Mag. Nat. Hist.," September, 1877), a most remarkable form of hydroid polyp discovered by him in the White Sea, where it lives at depths not exceeding five fathoms, adhering to the front end of the shell of the common *Tellina solidula*. The hydrorhiza in this singular polyp is represented by a sort of membranous expansion, from which the hydranths rise, and are surrounded for about one-fourth or one-fifth of their height by a chitinous tube, which the author regards as representing the hydrocaulus. The hydranth itself is a little, nearly cylindrical yellowish body, about one-twelfth of an inch long, truncated above, where it terminates in a simple rounded aperture. The single tentacle, which is filiform and very long, springs from one side of this primitive polyp-body a little above the middle. The gonophores or reproductive bodies are scattered among the ordinary hydranths, and spring, like them, from the membranous expansion. They have a short, thin stem, above which they are of an oval form, truncated above, and each of them develops in its interior a medusiform planoblast, having four radiating canals, each with two generative sacs, and sixteen tentacles. M. Mereschkowsky regards this hydroid as constituting the type of a distinct family of Athecata (Monobrachiidæ), nearly allied to the almost equally singular *Lar sabellarum* of Gosse, which possesses two tentacles. He points out that both these species, which are so scantily supplied with tentacles, take up their abode in peculiar positions—*Lar* upon the very margins of the tubes of *Sabellæ*, and *Monobrachium* upon one end of the shells of *Tellinæ*, in both cases in the spot where, by the exertions of the host, an abundant supply of nutriment will be brought easily within their reach. The great development of the tentacle in *Monobrachium* (it is three or four times as long as the body) he explains by the greater amount of nourishment which can be applied to the support of this single organ, coupled with the greater activity which it is obliged to display when compared with the tentacles of other hydroids. From a consideration of the characters of this and other hydroids, M. Mereschkowsky comes to the conclusion that the fundamental number in the hydroids is not four, as generally

supposed, but only two, so that the higher numbers exhibited in their tentacles and other organs are to be regarded as $2 \times n$, and he cites numerous examples which go far to establish his case. When uneven numbers occur, as in *Hydra*, for example, they are due to a certain amount of suppression or degradation; thus, *Hydra* would have $(2 \times 4) - 1 = 7$ tentacles. As the typical bitentaculate form, we have *Atractylis bitentaculata* cited, as in it the two tentacles are symmetrically placed; *Lar* as well as *Monobrachium* are to be regarded as degraded forms, the former having 6–4 and the latter 4-3 tentacles. The medusa of *Lar* is of a sex-radiate, and that of *Monobrachium* of a quadri-radiate type; and the remaining two tentacles in the former genus are not placed symmetrically, but at an angle of about 60° to each other.

Detection of Trichinæ.—M. Tikhomiroff suggests a new and easy method of detecting the presence of *Trichinæ* in suspected pork or sausages. The old method, consisting in the microscopic examination of slices of the suspected meat, may often lead to negative results, even when *Trichinæ* are present in abundance; the author proposes to isolate the muscular fibres, and states that their examination in this condition at once reveals the presence of *Trichinæ*. His process is as follows:—The flesh to be examined is cut with scissors into small fragments, soaked in distilled water, and then placed in a narrow-bottomed vessel with an approximately equivalent volume of chlorate of potash, and four volumes of concentrated nitric acid are added. The whole mass is then left for half-an-hour or more, and stirred occasionally with a glass rod. The fragments of muscle are then washed with distilled water, and put into a test-tube, one-third filled with distilled water, carefully corked, and shaken until the muscular tissue separates into its primitive bundles and fibres. The examination of these in a watch-glass, by the naked eye or with a lens, will immediately reveal the *Trichinæ* if present, as the fibres containing them at once attract the attention of the observer by the presence of fusiform swellings, whitish at the circumference, darker in the centre, along the primitive fibres. The microscope then easily tests the correctness of this rough investigation.—*Bull. Soc. Imp. Nat. Moscou*, 1877, No. 1.

The Colorado Beetle.—This malevolent animal still continues to occupy a good deal of the public attention, although, after the many false alarms that we have had, it is really hard to say how far the outcry in Europe is justified. The little scourge has been honoured by a discourse by Mr. McLachlan at the meeting of the British Association. That gentleman upholds an opinion which has been commonly expressed by entomologists, that the beetle, if it comes to us at all, will come in a chance fashion, by flying on board shipping at one of the American Atlantic ports, where it is now abundant. Dr. Andrew Wilson has written a small pamphlet on the insect, published by Messrs. W. & A. K. Johnston, and illustrated with enlarged figures of the true Colorado Beetle and the "Bogus Potato Bug;" this we have not seen, but we have been informed that it is good. —Messrs. Routledge have reprinted one of the admirable reports of Mr. C. V. Riley, of Missouri, from whose writings nearly all who have treated of the beetle have derived a very considerable part of their information. Enlarged drawings of the beetle may be seen stuck up in the windows of newspaper offices, &c., in various parts of the town, and our

publishers have produced an admirable large coloured figure of it, from the pencil of Mr. E. C. Rye.—Finally, Messrs. Stollwerck Brothers, of Cologne, have prepared wax models of the insect in all its stages, which, although not accurate in every detail, give an excellent idea of this pigmy bugbear.

Metamorphosis of the Dragon Fly.—According to a memoir presented to the French Academy of Sciences by M. Jousset de Bellesme ("Comptes rendus," August 20), the well-known enlargement of the body of the common dragon fly (*Libellula depressa*), and the expansion of its wings, soon after its emergence from the skin of the pupa, are effected in a rather singular manner. The author says that the animal *swallows* a great quantity of air and collects it in the intestine, which is thus greatly distended, filling almost the whole body-cavity and pressing the other organs against the skin. "Under the influence of this energetic pressure," he says, "the blood is driven forcibly towards the periphery, distends the eyes, and gives the head its definitive form; then, penetrating into the wing, between the two membranes which are separate up to this moment, it accumulates therein, unfolds it and circulates in it, depositing the pigment which is destined to colour it. At the same time the integuments, which are distended and bathed by the nutritive fluid, become coloured and acquire the solidity necessary for the insect." These statements are curious, if correct.

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